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Guidelines for Waste Characterization Studies in the State of Washington

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INTRODUCTION AND OVERVIEW

Effective solid waste management begins with knowing what is in the waste stream – how much of which types of material is disposed by each generator type. This basic information is essential to all aspects of policy and program implementation. It can be used for purposes such as:

- obtaining information to quantify recyclables or recoverables and to prioritize recovery opportunities
- establishing a baseline for continued long-term measurement of system performance
- understanding the differences between waste substreams so targeted recycling programs can be designed, implemented, and monitored
- comparing waste composition and waste diversion accomplishments among jurisdictions with different solid waste policies.

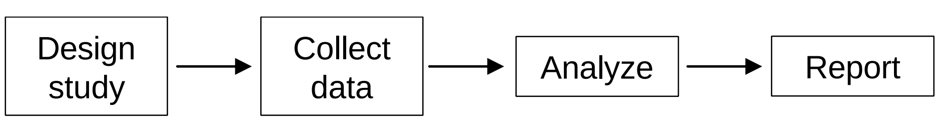
This document presents guidelines and recommendations for conducting waste characterization studies within the State of Washington. The structure of the document follows the basic structure of waste characterization studies.

Each waste characterization study begins with a *design* phase. The objectives of the study are detailed, and it's scope is defined. Basic methods for data collection and analysis are selected, and a design is developed based on certain principles.

Next is the *data collection* phase. A chapter in this document describes the many different ways of collecting data on waste quantity and composition, in a variety of settings.

Third is the *analysis* phase. The analysis chapter of this document presents a standard method for use by researchers.

Finally, there is the *reporting* phase. This document recommends standardized formats for recording and reporting data.



The guidelines presented in this document are intended to assist local governments in preparing for and implementing waste characterization studies, as well as to encourage the use of common design practices that will make studies more comparable across jurisdictions.

WASTE CHARACTERIZATION STUDY DESIGN

A waste characterization study typically involves development of two kinds of estimates: (1) an estimate of the *composition* of the waste with respect to a list of clearly defined materials and (2) an estimate of the *quantity* of waste. In most cases, both parts are equally important.

An estimate of waste composition is usually expressed in terms of the estimated *percent by weight* that each material contributes to the waste stream. The estimated percents are often shown with associated “error ranges” derived through statistical analysis. *Weight* is the standard used in most studies. The composition estimate is obtained by characterizing samples of actual waste, either by hand-sorting the samples or by characterizing them visually.

An estimate of the quantity of waste may be developed through a variety of methods which are described later in this document. The quantity of waste is usually expressed in terms of the tons disposed during a certain time period (e.g., tons per year). Combining the composition estimate and the quantity estimate permits the calculation of the amount, generally measured in tons, of each individual material that is disposed during the given time period.

The entire disposed waste stream is usually too complicated to address with a single approach to data collection, because disposed waste is generated by a variety of sources (e.g., residences, businesses, industry, agriculture, etc.), and because it is transported to disposal facilities through a variety of means. Indeed, some waste (such as crop residue or manure left on fields) is not transported to a permitted disposal facility at all, but rather is disposed at the location where it was generated. Therefore, it is helpful to envision the entire waste stream as being composed of several *sectors* of waste, and it is important to consider which sectors should be examined in any study that is planned. (A diagram of the waste sectors that comprise the entire waste stream appears on page 12.) One of the functions of this document is to provide standard definitions of waste sectors that can be used, when appropriate, in waste characterization studies conducted in the State of Washington.

In every waste characterization study, the precision of a composition estimate depends on the number of waste samples that are characterized, the inherent variability of the waste in a particular sector, and the quality of the data collection work. Characterizing more samples almost always improves the precision of the composition estimate, but there also is a point of diminishing returns with respect to the additional accuracy obtained with each additional sample. Waste from the commercial, construction/demolition, and self-haul sectors is usually more variable in terms of composition than waste from the commercially-hauled residential sector.

CHOOSING THE RIGHT DATA COLLECTION APPROACH

A waste characterization study is never a simple undertaking, but its complexity depends on the nature of the waste stream being studied and the level of detail required in the study’s findings. The general approach that is chosen for a waste characterization study should provide data at a sufficient level of detail to inform waste management decisions. A waste characterization study also must be designed to fit within budgetary constraints.[1]

The paragraphs below provide a brief overview of eight general approaches to collecting data about solid waste. Depending on the type of information that is expected from the waste characterization study, the approaches described below may be used singly or in combinations.

(1) **Hand-sorting of Waste Samples Obtained from Vehicles at the Disposal Facility** – This method produces the most accurate waste characterization data, and it is especially suitable for waste that is typically composed of many small pieces of numerous materials. Generally, an entire vehicle-load of waste is identified for sampling, but a only a portion of the load is pulled out for actual sorting. This method is nearly essential for thorough characterization of residential or commercial waste. It is less useful in characterizing waste that typically consists of large piece of material, such as some loads of construction and demolition waste. Because the method is employed at the disposal facility, it is of little use in correlating waste composition with specific types of waste generators, such as particular types of business.

(2) **Visual Characterization of Waste Samples Obtained from Vehicles** – This method is ideally suited for waste that is taken to a disposal facility and that arrives in loads that are fairly homogenous individually (even if loads are markedly different from one another). Waste loads from various construction, demolition, and landscaping activities are often suitable for visual characterization, because an individual load often contains just a few materials. The usual approach in visual characterization is to estimate the composition of the entire load and to correlate the visual estimate with the net weight of the load.

(3) **Hand-sorting of Waste Samples Obtained from Waste Generators** – This study method produces waste composition data that can be correlated to specific types of waste generators, such as specific categories of business or industry, multifamily buildings, or single-family residences in specific neighborhoods. Waste samples are obtained at the location where they were generated – e.g., from the dumpsters or disposal areas of the business or building in question.

[1] While it is not possible in this document to estimate the cost of every type of waste characterization study, it is possible to provide some examples of expected costs. A study based at a disposal site, involving 80 samples of residential waste, 120 samples of commercial waste, and 120 samples of self-haul waste might be expected to cost between $80,000 and $120,000 in 2003 dollars. A study of waste at the generator level (i.e., visits to individual businesses) is relatively more expensive on a per-sample basis.

(4) **Visual Characterization of Waste Samples Obtained from Waste Generators** – This method of waste characterization is ideal for wastes that are nearly homogeneous, such as mill tailings, agricultural chaff, sawdust, etc. Hand-sorting is not necessary to characterize these wastes.

(5) **Quantification of Waste through Use of a Vehicle Survey** – This method quantifies the waste that arrives at a disposal facility according to waste sector. Since disposal facilities often do not classify disposed waste according to the same *waste sectors* that are used in municipal solid waste planning or waste characterization studies, it is sometimes necessary to use statistically valid surveying techniques to determine the portion of a facility's disposed tonnage that corresponds to each sector. The portions that are revealed through the vehicle survey are then applied to a known total amount of waste that is disposed at the facility during a given time period.

(6) **Quantification of Waste by Examination of Records at the Disposal Facility** – Most disposal facilities keep transaction records that reflect the tonnage brought for disposal. In cases where the facility classifies waste according to the same sectors that are considered in the waste characterization study, facility records can provide thorough and reliable data to show the portion of a facility's disposed tonnage that corresponds to each sector. The portions that are revealed in the records are then applied to a known total amount of waste that is disposed at the facility during a given time period.

Examples of data that could be collected in a waste characterization study:

- Data about the composition of disposed MSW associated with a certain type of vehicle – e.g., waste from single-family homes that is collected in packer trucks – often can be obtained at the landfill or transfer station.
- Data about the disposal practices of certain types of residence – e.g., homes with large lawns – can often be obtained by examining MSW collected from designated routes that lie within neighborhoods containing that type of residence.
- Data about the waste generation and disposal practices of certain types of business – e.g., grocery stores – usually must be obtained at the site of the businesses themselves.
- Data about the quantity of disposed MSW that is associated with a particular type of vehicle – e.g. packer trucks carrying waste from single-family residences – is best obtained at the disposal facility, either through primary data collection methods or through examination of the facility's records.
- Data about the quantity of waste created and/or disposed by a particular type of waste generator – e.g. grocery stores – is best obtained either by measuring it at the point of generation or by examining records kept by the relevant business or its waste hauler.

(7) **Quantification of Waste through Measurements at the Point of Generation** – This method of quantifying waste involves visiting or contacting waste generators (e.g., businesses, apartment buildings, etc.) and determining through measurement or observation the amount of waste disposed during a given time period. Since waste generation is highly variable from place to place, or from one time to another, it is advisable to collect many data points in order to develop a reliable estimate of the

average amount of waste disposed by that class of waste generator. Typically, estimates of generation are correlated with another variable that describes the generator, such as number of employees, number of acres, etc. This correlation permits estimates of waste quantities to be “scaled up” to a level larger than the individual generator – e.g. to the countywide or statewide level.

(8) **Quantification of Waste by Examination of Records at the Point of Generation** – Some businesses and institutions maintain records that reflect the amount of waste disposed over time. This information often can be found in invoices from the waste hauler. Typically, the amount of waste is expressed in terms of *volume* rather than weight, so a volume-to-weight conversion factor may be necessary in order to quantify the weight of waste disposed.

GENERAL PRINCIPLES

REPRESENTATIVENESS OF DATA

Regardless of which of the eight general approaches are chosen for data collection, it is important to design the study in a way that collects data that is representative of the entire segment of the waste stream being studied. Some questions that can be considered in order to determine whether a study design will produce representative data include:

- Are there segments of the waste stream that will not be encountered during the planned data collection activities? If so, what is the likelihood that those segments are significantly different (in either quantity or composition) from the segments for which data *is* being collected? The study should not “ignore” segments of the waste stream during data collection if it is going to represent those segments in its conclusions.
- Is one segment of the waste stream overrepresented during data collection activities compared to another segment? If so, is it possible to modify the data collection approach to avoid this overrepresentation? (Even if it is not possible to modify the data collection approach, there may be ways to correct for a biased data collection approach later during analysis of the data.)

The sections below describe common considerations related to the representativeness of data collected in waste characterization studies.

DECIDING WHEN TO COLLECT DATA

COLLECTING DATA IN MULTIPLE SEASONS

If it is reasonable to believe that important aspects of the waste sectors being studied vary by season, then the data should be collected during multiple seasons. For example, if a study is intended to determine the amount of yard waste that is disposed, then it should collect data during seasons when yard waste disposal patterns are different, in order to develop a complete picture of yard waste disposal. Disposal rates and characteristics may be expected to vary by season for many materials, such as:

- soft-drink bottles, which may be bought and discarded more frequently during warm months
- waste generated from household clean-up activities, such as "spring cleaning"
- agricultural wastes from seasonal crops
- yard wastes
- construction wastes from seasonal building activities

Both the composition and the quantity of waste disposal may vary by season. In certain parts of Washington, for example, waste disposal quantities change with seasonal influx of tourists and part-time residents, as well as with seasonal changes in economic activity. Therefore, the study designer should consider both aspects of the waste characterization study – composition and quantity – in relation to seasonal changes.

> <u>Example of timing the data collection</u> to represent a week-long cycle of waste disposal:
>
> At a certain landfill, vehicles carrying self-hauled waste arrive six days every week. The ones arriving on weekdays generally come from commercial operations, whereas the ones arriving on Saturdays include a greater number of residents bringing waste from their homes. The residential waste is assumed to have different characteristics than the commercial waste. The County wants to develop a composition profile for all self-hauled waste combined, but it cannot afford to collect data for all six days that make up a complete weekly cycle.
>
> In order to represent the entire week of waste disposal, the County decides to collect and sort samples of self-hauled waste on one weekday and one Saturday. This approach allows the county to collect data that is representative of the entire week-long "cycle" of self-hauled waste disposal. Later, when the County develops composition estimates based on data from the waste sorts, it can devise a calculation method that allows the single weekday to "stand in for" the five weekdays in a week-long cycle, while data from the Saturday sort will stand in for the single Saturday in the cycle. (This method of assigning different importance to certain data during the analysis is described on page 31 of this document.)

Collecting Data at Different Times of the Day or Week

Waste disposal patterns often vary according to the time of day or week. This may be true at disposal facilities where, for example, packer trucks carrying single-family residential waste may arrive disproportionately in the early morning hours and on weekdays rather than weekends. This may also be true at the point of waste generation, where for example, a manufacturing plant may take its waste outside to the dumpsters on certain days and not on other days. The study design should include plans either (1) to collect data that covers the *entire* period of disposal, or (2) to collect data that may be assembled later in a way that *represents* the entire period.

Deciding Where to Collect Data

Several factors determine what constitutes the best location for data collection. The scenarios presented below illustrate some of the considerations that affect the choice of location.

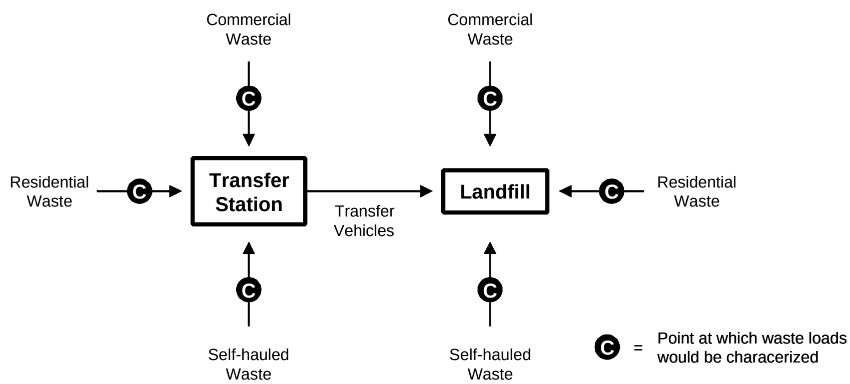
COLLECTING COMPOSITION DATA AT DISPOSAL FACILITIES

If there are two or more disposal facilities that handle the waste stream that is being studied, it is important to consider whether the waste arriving at the different facilities might have different characteristics. If this seems likely, then waste should be characterized at each location where it is expected to be “unique”.

If two disposal facilities handle very different amounts of waste, then it may be advisable to ignore the smaller facility for the purpose of collecting composition data, unless composition data from the smaller facility can reasonably be expected to enhance material recovery and diversion efforts.

If the study addresses waste at transfer stations as well as landfills, then it is advisable to collect composition data at both types of facilities. However, the sampling plan should ensure that waste that passes through the transfer station does not have a “double chance” of being examined again when it arrives at the landfill. Generally, waste that is being transported from the transfer station to the landfill should not be characterized, because it is a mixture of waste from several sectors. The diagram below illustrates the points at which waste should be characterized in this scenario.

Characterizing Waste at Transfer Stations and Landfills



COLLECTING QUANTITY DATA AT DISPOSAL FACILITIES

If vehicle surveys are used to quantify waste at a facility with multiple entrances, and different waste arrives at each entrance, then the study design might either (1) position multiple surveyors simultaneously at all entrances, or (2) rotate a single surveyor through all entrances. In the first instance, multiple surveyors would be positioned to count and classify all the tons of waste entering each gatehouse during the same period of time, thereby getting data that reflects how much waste is associated with each sector. In the second instance, the single surveyor essentially would get a “snapshot” of data with respect to each of the facility’s entrances. Those snapshots would be used to extrapolate the tonnage and sector allocation of the waste arriving at each gate individually. The extrapolations for each gate would then be added together to produce a complete picture of the waste arriving at the whole facility.

COLLECTING DATA AT THE POINT OF GENERATION

When data is collected at the point of generation (e.g., at the location of the business, the apartment building, the farm, etc.), the objective of the study usually is to characterize the waste stream produced by a particular class of generators (e.g., all aircraft manufacturers, all apartment buildings, all wheat farms, etc.). In this case, the first task is to define the class of waste generator that is being studied. After that is done, the study design must include a method of selecting the sites (e.g., which business, which apartment building, etc.) where data is to be collected. The choice of method usually depends on how much the members of the generator class vary in terms of the quantity of the waste they produce, or in terms of their size.

If a handful of locations generates more waste than all of the other locations in the class, then the existing population of generators should be divided into size-groups, and a plan should be developed to gather most of the data from the larger generators. In many cases, this can be done using the *80/20 rule*, which predicts that 80% of waste is generated by 20% of the largest generators. If the *80/20 rule* is believed to apply, then approximately 80% of the generators selected for study should come from the larger size group. Generators should then be selected randomly for study within each size group.

Later, during the analysis phase of the study, the two size groups should be analyzed separately before results are combined to make statements about the entire class of generators. A method for doing this is described on page 31.

If the study designers believe a different "rule" regarding the size of businesses applies in the particular case, such as a *90/10 rule*, then they should use that as a guide instead. In the most extreme case, a single generator may be responsible for nearly all of the waste associated with its generator class. In that case, it is advisable to ignore the generators that make a negligible contribution to the waste stream.

If there is not much disparity among locations in terms of size and waste generation, or if the existence of such disparity is unknown, then all generators in the class may be simply grouped together. Generators should then be selected randomly for study from the pooled group.

Since the quantity of waste generated at individual locations is difficult to estimate before the study has begun, a different variable can serve as a proxy for waste generation when the sampling plan is being developed. It is often possible to use a count of employees on-site, number of acres in production, or a similar figure to compare the locations within a generator class. The variable that is chosen should be one that is easily obtained from government records or publicly accessible sources of information.

When using a generator-based approach to waste characterization, it is useful to collect quantity and composition data from every generator that participates in the study. As a general rule, if a generator is selected to provide one type of data, it should also be used to provide the other type.

USE OF RANDOM SAMPLING METHODS IN DATA COLLECTION

Once a segment of the waste stream has been identified and defined, the decision about which representatives of that segment to use for data collection should be left to random or representative selection methods whenever possible. At this point in the study design, it is important to keep in mind the *sampling unit*. **The *sampling unit* is the thing that will be chosen to represent others of its kind.** For example, when composition data is gathered for single-family residential waste at disposal facilities, the *sampling unit* is the packer truck that brings waste to the disposal facility. (Studies are designed this way because it is relatively easy to develop a selection procedure for packer trucks. It would be more difficult to design a study that defined the sampling unit to be a *cubic yard of waste*, because waste arriving at disposal facilities doesn't come in discrete cubic-yard-sized bundles.) Likewise, when composition or quantity data is gathered for machine shops, the individual shop is the sampling unit.

The sections below present guidelines and examples for the use of random or representative selection of *sampling units*.

RANDOM SELECTION OF VEHICLE LOADS TO GATHER COMPOSITION DATA

When constructing a sampling plan based on vehicles, the quota of vehicles that should be sampled is compared to the number of vehicles of that type that are expected to arrive during the data collection period. For example, the sampling plan for single-family residential waste may call for eight samples from packer trucks, and the number of packer trucks arriving at the disposal facility on the sampling day may be 24. The study designer should choose ahead of time which vehicles will provide waste samples. The choice of vehicles may rely on either of the following approaches:

- random selection of collection routes and identification of the vehicles that correspond to those routes, in which case the designer would pre-select eight of the 24 routes randomly;
- systematic selection of vehicles based on the order in which they arrive at the facility, in which case the designer would develop a worksheet that allows the person selecting vehicles to count off every 3rd vehicle and divert it to the sampling crew.

If a hand-sorting method is used to characterize the waste sample, then the portion of a waste load that is pulled out for hand-sorting should be randomly chosen as well. This procedure is described on page 18.

RANDOM SELECTION OF DISPOSAL FACILITIES, WHEN APPROPRIATE

When there is more than one disposal facility at which data could be collected, there are several considerations in choosing where to go. Foremost is the question of which facilities handle the greatest amounts of waste. Data should be collected at those facilities that collectively handle a significant and representative portion of the waste stream being studied. If multiple facilities are approximately equivalent with respect to the quantity and mixture of wastes they receive, then it is permissible to use a random selection approach to assign data collection activities to some facilities and not others. However, if study resources permit, it is preferable to spread the data collection activities among multiple facilities.

If multiple days are planned for data collection, a random assignment of days to individual disposal facilities is recommended. However, logistical and scheduling complications may prevent a purely random assignment of days and locations.

RANDOM SELECTION OF LOCATIONS FOR GENERATOR–BASED STUDIES

Once the appropriate generator classes and size groups have been identified, representative generators from within each class and size group should be chosen in the most random method possible. Usually, this involves assembling a list of candidate generators from any available source – the telephone directory, commercial providers of mailing lists, the chamber of commerce, etc. A quota is set for the number of generators that are to be included in the study, and a certain number (more than the quota number) of generators is selected at random from the list. Generators are contacted, screened with respect to the criteria of the study, and scheduled for data collection visits.

Lists from which generators are chosen should be as comprehensive as possible. The process of recruiting generators to participate in waste characterization studies is often difficult, and it is not unusual to contact as many as ten generators in order to recruit one that is willing and eligible.

When waste is to be physically separated for hand-sorting and characterization (as opposed to visual characterization of homogenous piles of material), the choice of which waste to pull from refuse piles or dumpsters should be random. Procedures for this are recommended on page 19.

DESIGN A STUDY TO MAXIMIZE COMPATIBILITY WITH OTHER STUDIES

Waste characterization studies are often conducted to answer immediate questions related to the feasibility of recovering or diverting certain materials from the disposed waste stream locally. However, each study also represents an important opportunity to contribute to the knowledge and tools available to communities throughout the state and the nation. In several instances, waste planning efforts in Washington communities have been based on waste composition and quantity data that was collected in other communities inside or outside of the state. Therefore, in addition to the priority of designing a study to answer the immediate questions arising locally, the designer of a waste characterization study should endeavor to produce data that can be used by other communities too. One key to ensuring the usefulness of the data is to make it conform to certain conventions that other communities use as well. These conventions include:

- **Standard definitions of waste sectors** – Standard definitions for the sectors of the waste stream ensure that waste is counted in the same way in each study. A set of definitions for waste sectors and subsectors is presented in the following section of this document.
- **Standard definitions of materials in the waste stream** – The list and definitions of materials that are examined in a waste characterization study must be guided by the information needs of the study at hand. However, it is usually possible to design the list and definitions such that they are compatible with waste characterization studies conducted in other locations and in other years. This compatibility in material lists facilitates comparison of disposal behavior, recycling levels, and program performance. A recommended material list for waste characterization studies is presented in Appendix A.
- **Standardized recording and presentation of data** – There are some specific models for electronic recording and storage of data that facilitate analysis and make the sharing of data easier among jurisdictions. Examples and templates for these storage formats are presented on pages 35 and 36.

A SYSTEM FOR CLASSIFYING WASTE

The "universe" of solid waste is depicted in the figure on page 12. It can be divided in several ways to produce answers to the questions that lead to waste characterization studies. Typically, the "universe" of solid waste is studied in segments according to the destination of the waste (e.g., landfilled, recycled, or handled in another way), its origin (e.g., the type of business or household that produced it), who transported it to the disposal location, and the type of vehicle used to transport it. The typical waste characterization study will consider only some of these dimensions at one time. The classifications are described below.

CLASSIFYING WASTE BY ITS DESTINATION

The universe of solid waste can be classified according to three main destinations.

- **Waste sent to landfill** includes waste that is disposed in permitted solid waste disposal facilities.

- **Waste put to beneficial use** includes materials that are recycled, reused, or incorporated into another manufacturing or agricultural process, and it includes any material that is used for some beneficial purpose.

- **Waste disposed in other ways** includes any waste disposed under conditions not described above. This typically means material that is left on the ground for no beneficial purpose.

The majority of waste characterization studies focus on waste that is sent to landfills, but a complete accounting of the solid waste produced by any enterprise or any part of society would consider the other sectors of waste as well.

CLASSIFYING WASTE BY ITS ORIGIN

The universe of solid waste also may be divided into three *sectors*, based on the origin of the waste in question. The three *sectors* represent different parts of society and may be expected to produce waste with differing characteristics. The *sectors* and *subsectors* of solid waste are described below.

- **Industrial waste** originates from businesses that are engaged in agriculture, resource extraction, or manufacturing. Businesses that have Standard Industrial Classification (SIC) codes ranging from 01 to 40 (at the 2-digit level of detail) are classified as industrial for this purpose.

    - **Subsectors of industrial waste** include groupings of similar businesses based on SIC code. For example, one such grouping is the *mining* subsector of industry, which is defined to include businesses with SIC codes starting with the digits 10, 12, 13 or 14. A complete list of the recommended groupings for industrial waste is found in Appendix G.

    - **Construction and demolition waste** (abbreviated as C&D waste) is a subsector of industrial waste that often merits special attention, even if a waste characterization study is not designed to focus on other subsectors of industrial waste. C&D waste is produced during building, remodeling, demolition, and sometimes landclearing activities, and it represents a major portion of waste that is disposed at landfills and through other methods. C&D waste is disposed in high quantities and is composed of different materials than are found in other types of waste. It often contains materials that are highly recoverable.

Entire Waste Stream

Industrial & Agricultural Waste

	Sent to Landfill: Commercially Hauled	Sent to Landfill: Self-Hauled	Disposed in Other Ways	Beneficial Use, Recycling, Recovery
Industry Groups	Orchards			
	Field Crops			
	Berries & Vegetables			
	Livestock			
	Mining			
	Construction			
	Paper			
	Logging			
	Food Mfg.			
	Etc...			

Commercial & Institutional Waste

	Sent to Landfill: Commercially Hauled	Sent to Landfill: Self-Hauled	Disposed in Other Ways	Beneficial Use, Recycling, Recovery
Commercial Groups	Restaurants			
	Government Facilities			
	Retail Food Stores			
	Wholesale Trade			
	Retail Trade Stores			
	Medical & Health Services			
	Finance, Insurance & Real Estate			
	Hotel & Lodging Services			
	Etc...			

Consumer (Residential) Waste

Sent to Landfill: Commercially Hauled	Sent to Landfill: Self-Hauled	Disposed in Other Ways	Beneficial Use, Recycling, Recovery
Single-family housing			
Multifamily housing			

Other wastes tracked separately

Treated sewage sludge delivered to landfills

Etc...

- **Commercial waste** originates from businesses, government agencies, and institutions engaged in any activity other than those associated with industry as defined above. Some examples of commercial waste include waste originating from retail and wholesale businesses, medical facilities, schools, government agencies, and park and street maintenance. Commercial entities have SIC codes ranging from 41 to 97 (at the 2-digit level of detail).

    - **Subsectors of commercial waste** include groupings of similar businesses based on SIC code. For example, one such grouping is the *medical and health services* subsector, which is defined to include businesses with SIC codes starting with the digits 80. A complete list of the recommended groupings for industrial waste is found in Appendix G.

- **Consumer waste** originates from households as a function of the "living" activities in those households. In the strict definition, it does not include waste generated by business activity conducted at households, although for practical purposes it can be difficult to distinguish home-business waste from consumer waste in a characterization study. Consumer waste also does not include waste generated by construction, remodeling, or landscaping activities that are conducted by hired companies at a residential location.

    - **Single-family consumer waste** originates from households that do not share trash cans or dumpsters with very many other households. Typically, the definition of *single-family* in waste characterization studies encompasses buildings containing from one to four dwelling units. Single-family waste is often collected in packer trucks on routes that service only single-family dwellings.

    - **Multifamily consumer waste** originates from households that share trash cans or dumpsters. Typically, the definition of *multifamily* includes buildings containing more than four dwelling units. Multifamily waste often differs in composition from single-family waste by containing fewer materials associated with yard maintenance. Multifamily waste is often collected in packer trucks on routes that service commercial establishments as well as multifamily buildings.

- **Other wastes** often are tracked and counted separately by waste disposal facilities. Examples of other waste include sludge from sewage treatment plants, petroleum-contaminated soils, asbestos, and other special wastes.

CLASSIFYING WASTE ACCORDING TO WHO HAULS IT

Quantity and composition characteristics are often different for waste that is collected by waste hauling companies and waste that is hauled by the household or business that generated it. Therefore, in most studies that address waste taken to solid waste facilities, it is important to examine commercially-collected and self-hauled waste separately.

CLASSIFYING WASTE ACCORDING TO VEHICLE TYPE

For some types of waste, such as C&D and self-hauled waste, the quantity and composition are correlated with the type of vehicle that brings the waste to the disposal facility. Therefore, in some cases, it is helpful to consider separately the waste arriving on different vehicle types. A typical classification scheme for vehicles might include (1) packer trucks, (2) dump trucks, (3) roll-off boxes or drop boxes, (4) other large vehicles, and (5) vehicles the size of a pickup truck or smaller.

MAKING SENSE OF THE CLASSIFICATIONS

Taken together, the classifications of waste described above represent a system for ensuring that waste characterization studies count things in the same way. However, the typical waste characterization study will consider only a portion of the waste included in the "entire waste stream" depicted in the figure above and will therefore address fewer classifications of waste. Some examples of the scope of typical waste characterization studies are presented below.

Example: A study of municipal solid waste (MSW) as it arrives at the landfill

Managers of a landfill want to know the proportions of commercially-hauled waste arriving from the commercial/industrial and consumer sectors, and they want information about waste composition. They design a study that classifies waste loads arriving at the facility as either single-family, multifamily, commercial or industrial. As loads arrive during the study period, they record the net weight of each load in the proper category, in order to determine the proportions later. They also select loads from each category for sampling and characterization, to produce data that will portray the composition of each of the identified categories of waste.

This study examines commercially hauled waste taken to landfills. It does not make distinctions according to business group or industry group. It does not address waste disposed through other methods or allocated to beneficial use.

Example: A study of commercial waste seeks to correlate waste composition with type of business

In order to correlate waste composition with type of business, city managers design a study that entails visits to selected businesses belonging to particular groups of interest (e.g., grocery stores, home & garden stores, and other large retail stores). Quantities of waste are measured in the dumpsters and associated with known time-periods of waste generation. Samples of waste are taken from dumpsters and characterized.

This study examines commercial waste from selected industry groups. It does not make distinctions according to hauling method. It does not address waste disposed through other methods or allocated to beneficial use.

DATA COLLECTION

This section presents the "how to" of collecting data in waste characterization studies. It provides recommended methods for addressing each type of waste characterization study and collecting data with respect to each type of waste suggested in the diagram of the waste stream shown on page 12.

OVERVIEW OF DATA COLLECTION AND CALCULATION ISSUES

The data collection aspect of a waste characterization study begins with the construction of a *sampling plan*, which determines when and where data will be collected and specifies the exact pieces of data that will be collected. Construction of the sampling plan often involves nearly as much work as collecting data in the field.

DEFINING AND ISOLATING THE SAMPLE

The first step in designing the sampling plan is to confirm which waste sectors are to be studied. (Please refer to the diagram on page 12.) This means determining which of the "dimensions" of waste variability to pay attention to. (As described in the previous section, the typical "dimensions" of waste variability are its destination, its origin, the type of hauler, and the type of vehicle.) As a guide in choosing which "dimensions" to consider, the study designer should predict which ones are likely to correlate with differences in waste composition while also producing information that can be acted upon by policymakers (see examples at right).

Next, a method should be devised for assigning a waste quantity to each waste sector that has been identified for study. In some cases the waste can be quantified, based on records maintained by waste haulers or disposal facilities, before any field work takes place. More often, the data is not available to quantify waste precisely, and only rough estimates can be made. In that case, the study designer should devise a survey-based or measurement-based approach to quantify each waste sector.

Then, based on preliminary estimates of the relative quantities associated with each waste

Examples of defining waste sectors

Waste sectors usually are identified in a waste characterization study such that they meet two criteria: (1) they can be isolated and studied, and (2) they can be addressed through policy measures.

Many waste chraacterization studies include an examination of single-family residential waste, because that sector is easily studied and is relatively easy to address with waste reduction marketing, messages, and policies.

Some studies in recent years have emphasized collection of waste from specific commercial groups, because those groups were believed to produce waste with relatively high amounts of recoverable waste, such as organics for composting or plastics for recycling.

sector, the study designer should prioritize the sectors and decide which ones should be characterized through sampling. Usually, the waste sectors that should be sampled are the ones that represent the largest amounts of waste. However, if a waste sector seems especially easy to address with recycling or diversion programs, it may be assigned a higher priority than sectors that are expected to be difficult to address. Likewise, if a waste sector is expected to contain a greater concentration of valuable materials or harmful materials, it may be assigned a higher priority.

The paragraphs below describe methods for deciding how to get the waste sample for the purpose of collecting waste *composition* data. (It is assumed that waste *quantity* estimates will be developed for all locations and all sectors of waste, even if those estimates are rough, and even if composition data is not collected for those waste sectors.) Specific methods for collecting composition data and quantity data are described later in this chapter.

PROCEDURES FOR SELECTING DISPOSAL FACILITIES

When multiple solid waste facilities handle the waste sectors being addressed in a study, the designers should endeavor to collect composition data from each targeted sector of waste arriving at each of the facilities. If too many facilities exist in the solid waste system to make sampling at all of the facilities practical, then facilities should be selected using the method described below.

- ❑ First, rank the solid waste facilities in terms of the estimated amounts of "direct-hauled" waste from targeted sectors that arrives at each facility. (Do not allow waste to be "counted twice" by considering it first at a transfer station and considering it again in the transfer trailers going from the transfer station to the landfill or railhead.)

- ❑ Second, determine the "cut-off point" that separates the facilities that handle the largest amount of the targeted waste sectors from those that handle smaller amounts. Usually, the cut-off point distinguishes the set of facilities that collectively handle approximately 70% to 80% of the targeted waste.

- ❑ Third, determine how many samples may be collected and how many facilities may be visited, given the resources available for the waste characterization study. Assume that the most efficient approach to waste sampling is to allow the sampling crew to work at a single location for one or more complete days, rather than expecting the crew to "hop" from one facility to another on the same day.

- ❑ Fourth, use a random selection method to choose the requisite number of facilities from among those that handle the largest amounts of the targeted waste.

- ❑ Fifth, for the facilities where waste sampling does not occur, correlate the waste in each sector to the waste at the facilities where sampling does occur. For example, if single family waste is sampled at one large facility, while two small facilities are not visited at all, then single-family waste at the smaller facilities should be assumed to have the same composition as that discovered at the larger facility. Usually, this issue is considered later during the analysis phase of the study.

PROCEDURE FOR SELECTING LOADS TO SAMPLE AT DISPOSAL FACILITIES

When obtaining waste samples at disposal facilities, the most practical approach is usually to select certain vehicles through a systematic selection process and then to characterize the loads, or portions of the loads, that are delivered by the selected vehicles. The recommended procedure for selecting loads to sample is described below. The process should be repeated for each targeted waste sector that is to be sampled at the facility.

- First, during construction of the sampling plan, the study designer should determine how many loads representing the targeted waste sector arrive at the facility on the chosen sampling day. Let the variable *A* represent that number of loads.

- Second, the study designer should allow some margin for uncertainty in the number of loads that will arrive on the sampling day. It can be extremely disruptive to a waste characterization operation if the sorting crew is left at the end of the day without having enough samples to sort. In order to create a safety margin, the designer should reduce by approximately 20% the number of loads that the study depends on to arrive – i.e. reduce the number of loads expected for planning purposes to approximately 0.8 x *A*.

- Third, the designer should determine how many waste samples are to be obtained and characterized for the particular waste sector on the scheduled day. Designate the targeted number of samples with the variable *b*.

  As a guideline for determining the number of samples to capture in a day, an untrained sorting crew can sort approximately 8 to 10 samples by hand in one day, when the samples weigh approximately 200 pounds and are composed of very mixed materials (as is most consumer waste). A highly trained sorting crew can sort as many as 15 consumer waste samples in one day. If visual characterization methods are used, a single person can characterize approximately 25 to 30 loads in one day.

- Fourth, the requisite number of samples, *b*, will be chosen systematically from the 0.8 x *A* loads available for sampling. The number of loads available for sampling will be divided by *a* to determine the interval, *c*, at which loads will be chosen for sampling.

- Fifth, a random starting point should be chosen, and sampling should then proceed throughout the day. Based on a randomly chosen integer, *d*, between 1 and *b*, the sampling crew should obtain the first sample of the day from the d^{th} load of the targeted waste sector that arrives on the sampling day. Every c^{th} load thereafter should be sampled, until the quota of samples is met for the day.

  It is often helpful to place a staff member at the entrance to the facility to count loads as they arrive and to interview drivers to determine the waste sector arriving in each load.

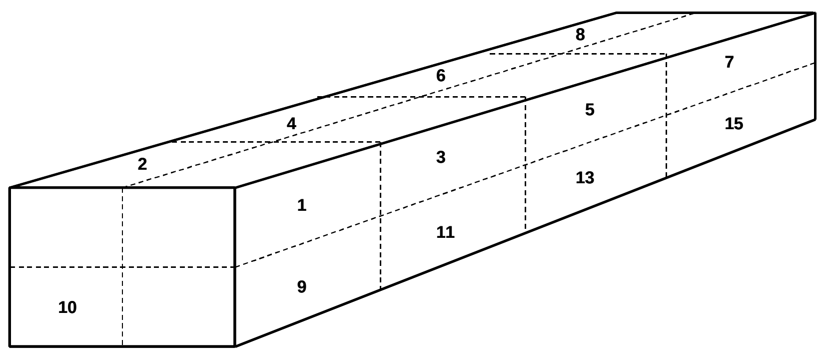
> *A* is the expected number of loads for the day
>
> *b* is the targeted number of samples
>
> *c* is the interval at which loads will be selected for sampling
>
> *d* is the number corresponding to the first load that is sampled

PROCEDURE FOR SELECTING THE WASTE SAMPLE FROM A LOAD AT A DISPOSAL FACILITY

The appropriate procedure for selecting the waste from a load that is to be characterized (i.e., selecting the actual waste sample) depends on the method of characterization. If visual composition estimates are being used, then the entire load should be characterized. If hand-sorting is being done, then a manageable portion of the load should be selected through the randomizing process described below. The procedures for characterizing the samples are described in a later section.

- ❑ First, tip the load onto the facility floor or onto the ground, such that it forms a symmetrical or elongated pile.

- ❑ Second, envision a grid that divides the load into multiple sections. The appropriate number of sections depends on the size of the load. For loads tipped from packer trucks or other large vehicles, envision a grid that divides the load into 16 sections, as shown in the figure below. For loads tipped from smaller vehicles, envision the load being divided into 8 sections.



- ❑ Third, choose one of the cells through a random selection process. Extract the requisite amount of material from the selected cell and move it to the sorting area. See the section on *recommended numbers and sizes of samples* (page 24) for guidelines about how much waste to obtain from the pile.

  It is important to develop a method of pulling the material from the pile in a way that does not consciously favor or exclude any particular material or any size of object. Rigid adherence to the grid system can assist in avoiding such biases. If a large object extends beyond the chosen cell of the grid, the appropriate procedure is to estimate the percentage of the object's mass that lay within the selected cell, weigh the entire object, and then apply the percentage to the entire weight of the object.

PROCEDURES FOR SELECTING GENERATORS

When a waste sector in a characterization study is defined in terms of the origin of the waste, it becomes necessary to develop a procedure for selecting waste samples that are representative of the entire waste sector – i.e., that are representative of all of the waste disposed by the class of waste generators that is the focus of that part of the study. The procedure for selecting representative generators is described below.

- First, define the class of waste generator and decide whether size groupings also should be created. Cases where it is appropriate to establish multiple size groupings are when a handful of members of the class produce the overwhelming majority of the waste and when the composition of the waste is expected to correlate somehow with the size of the waste generator.

  It generally is not advisable to create more than three size categories for a class of waste generator. The unit for measuring the size of a waste generator would ideally be the number of tons of waste that each generator produces annually, but other proxy units such as number of employees, number of students, or number of acres are often used instead.

- Second, devise a method of random selection for choosing representative businesses, agencies, buildings, homes, etc., that belong to the class of generator. Usually this is done by establishing a comprehensive list of all the members of the class. The list may be compiled by someone with local knowledge of the generator class, or it may be taken from an existing source such as the phone book, or from various companies that are in the business of producing lists for marketing purposes. Two national companies that produce such lists are *ABI* and *Dun and Bradstreet*. Select members at random from the list and contact them to ensure they meet the criteria for being included in the desired class and/or size group of generators.

Procedures for Identifying the Sample at a Generator Location

The first step in characterizing the waste from a selected generator is to identify and distinguish the waste streams produced by the generator. When doing this, it is important to be mindful of the sectors of waste that are being considered in the larger waste characterization study. For example, if a selected generator produces some waste that is sent to landfill and some that is recycled, but the study intends to focus only on landfilled waste, then data collected from the generator should describe only the landfilled waste. However, even when the destination sectors of waste are properly distinguished, it is still possible for the generator to have multiple waste streams within each waste destination sector. As an example, consider the scenario presented in the adjacent sidebar.

Example of multiple waste streams within a waste category produced at a selected generator site

As part of a generator-based waste characterization study of orchards, a particular orchard is selected for study of the waste it sends to landfill. In discussions with the orchard owner, the researcher learns that waste is collected in two separate processes before it is picked up by the local waste hauler. In one process, scraps and miscellaneous trash from harvesting activities are placed in a dumpster which is emptied every week by the waste hauler. In the other process, scraps and wood pallets that accumulate from an on-site packing house are placed in a different dumpster, which also is collected every week.

Since the composition of the waste in the two dumpsters is known ahead of time to be different, the waste in each dumpster should be considered to represent a distinct waste stream for the purpose of obtaining a sample for characterization. Each waste stream should also be quantified separately so that data from each can be combined appropriately during the analysis phase of the study.

After all of the waste streams have been identified for a given waste destination sector at a generator, each waste stream should be characterized separately. In cases where a waste stream consists of a pure material (such as pure dirt or pure food scraps), it usually is not necessary to characterize the waste stream by sorting an actual sample. Rather, it is sufficient to quantify the waste stream and note that it is composed entirely of one material. In cases where the waste stream is not homogeneous, then hand-sorted or visual characterization methods should be applied to a sample of the waste.

If a sample is to be hand-sorted, then a method should be devised for selecting a sample at random from the available waste. If the waste is contained in a dumpster, then a vertical cross-section of waste weighing approximately 150 pounds should be extracted from the dumpster and placed in a container for transport to a location where it can be sorted. If there are multiple dumpsters, then one should be chosen at random to provide the sample. (However, multiple dumpsters may be an indication that there are actually multiple waste streams at the location. This possibility should be investigated before a waste sample is taken.)

COLLECTING DATA TO QUANTIFY WASTE

This section describes procedures for quantifying solid waste in different settings and different study approaches. In any waste characterization study that involves more than one waste sector (please refer to the figure on page 12), it is important to quantify each waste sector so their relative proportions can be known. Quantifying the waste also serves to make the data from composition estimates more useful. For example, when planning a material recovery operation, it may be more helpful to know that 200 pounds of aluminum can be recovered from the 20,000 pounds of solid waste that arrives at a facility each day than to know merely that the waste is composed 1% of aluminum.

QUANTIFYING WASTE AT DISPOSAL FACILITIES

Waste that is taken to a disposal facility may be quantified using either of two methods – by examining records of arriving loads that are kept by the facility or by conducting a survey of vehicles to count and classify waste as it arrives. In either case, it is important to verify that waste is being counted and classified in the same way by the study designer and the facility recordkeeper or vehicle surveyor. Ideally, solid waste facilities and study designers will count and classify solid waste in a systematic way that is compatible with the definitions of waste sectors presented earlier in this document.

The standard way of quantifying waste at disposal facilities is to express the amount of waste disposed, in terms of tons, for each waste sector over a year-long period. Therefore, the common unit in this type of waste quantification is *tons per year*.

USING EXISTING RECORDS

It is sometimes possible to rely on existing records to quantify and classify the waste that arrives at a disposal facility. However, at present it is unusual for a facility to classify waste in a way that is entirely consistent with the guidelines presented in this document. If records are used as the basis for quantity estimates, then there are two important considerations.

- The amount of solid waste taken to a facility may fluctuate by season or in response to changes in the local solid waste system (such as the opening or closing of other solid waste facilities). Therefore, it is better to use a fairly long time-period – ideally a year – as the basis for counting the amount of waste that enters the facility. Data from a shorter period of time, such as a monthly tabulation, can be used to extrapolate annual disposal, but it presents the risk of overlooking fluctuations that occurred outside the given month.
- Some facilities do not weigh every waste load that arrives, but instead assign weight estimates to certain types of loads. For example, loads transported to disposal facilities in small vehicles may be quantified using an "alternative minimum weight," which is an assumed net weight for all such loads. Other types of loads may have their net weight estimated, based on volume-to-weight conversion factors for materials such as dirt or concrete, or for mixed materials such as construction and demolition debris.

Assembling quantity estimates from records is often like putting a puzzle together. The total amount of solid waste entering the facility is usually known. Specific information may exist for some waste sectors but not for others. Therefore, it is often necessary to deduce the quantity of one waste sector based on information about other waste sectors. It usually is not possible to quantify every waste sector precisely, so estimates of their relative proportions are often used instead.

USING VEHICLE SURVEYS TO QUANTIFY WASTE

When it is not possible to quantify the relevant waste sectors through use of existing records, the alternative is to construct a survey that counts and classifies waste as it arrives at the facility. The procedure for designing a vehicle survey is outlined below.

- ❑ First, establish and define the waste sectors that will be tracked in the survey. It is recommended that the survey classify waste in a way that is compatible with the sectors shown in the diagram on page 12, but it usually is not necessary to classify waste at the finest level of detail suggested by the diagram.

- ❑ Second, determine the time period of the survey. The survey should collect data during one or more time periods, such that the data is representative of all of the waste arriving at the facility. The simplest way to accomplish this is to conduct the survey during an entire week of facility operations during what is believed to be a representative time of year, or perhaps during week-long periods in multiple seasons. If this would be too costly, then it is often possible to "piece together" portions of the facility's weekly disposal cycle. For example, the survey could be conducted on one weekday and one Saturday. Results from the weekday would be multiplied by 5 to determine the quantities of waste arriving on all weekdays of a weekly cycle. Results from the Saturday would then be added to complete the week-long picture.

- ❑ Third, if the facility has more than one entrance, devise a system for collecting data from each entrance such that it provides a representative picture of all of the waste that enters the facility. If different entrances handle different amounts or different waste sectors, then the results from each entrance should be "projected up" to a week-long period separately. Later, the estimates for each entrance may be added together to produce a week-long picture for the entire facility.

- ❑ Fourth, devise a method of quantifying each arriving waste load. If the facility has scales, arrange for all vehicles to be weighed before and after their loads have been tipped, and for weight and sector information to be recorded by the vehicle surveyor. If the facility does not have scales, devise a method for estimating load weights based on their measured volume (i.e., measuring their three dimensions with a tape measure) and on accepted volume-to-weight conversion factors. A set of volume-to-weight conversion factors appears in Appendix B of this document.

- ❑ Fifth, devise a form to use when conducting the vehicle survey. An example of a vehicle survey form appears on the following page. The basic information that should be collected on the survey form includes the waste sector to which each load belongs and the net weight of the load (or its dimensional measurements, if necessary). In cases where mixed loads arrive (e.g. loads containing a mixture of commercial waste and multifamily residential waste), it is acceptable to ask the driver of each vehicle to estimate the portion of the load that corresponds to each sector, to the nearest 10%.

- ❑ Sixth, implement the survey.

QUANTIFYING WASTE AT THE LOCATION WHERE IT IS GENERATED

When quantifying waste at the point of generation, it is sometimes possible to rely on the generator's own records, such as invoices from commercial waste haulers or receipts from disposal facilities. When that is not possible, the best approach is to measure the amount of waste that accumulates during a known time period and extrapolate a year's disposal from the measured amount. In either case, it is important to ensure that each distinct waste stream at the generator is quantified and characterized separately. The procedure for quantifying one waste stream at a generator location is outlined below.

- ❑ First, locate all of the places where waste from the particular waste stream accumulates. The locations may include trash cans, dumpsters, waste compactors, piles, etc.

- ❑ Second, define an *accumulation time* that will correspond to the amount of waste you will measure. For waste that is collected by a commercial hauler or is self-hauled to a disposal facility, the accumulation time is the time between when waste container was last emptied and when the accumulated waste is measured or weighed. Some points to consider when defining the accumulation time are presented below.
    - In most cases, accumulation time can be measured in terms of days or fractions of days.
    - If the generator is a facility that operates with irregular shifts, then it may be more accurate to measure accumulation time in terms of the number of hours that the facility has operated since the last waste pick-up. This approach also is appropriate when waste is collected more frequently than twice per week.

- It is important to make the accumulation time as representative as possible of the entire waste collection cycle at the generator location. For example, if the majority of a generator's waste is taken to the dumpsters on Fridays, then the accumulation time for the purpose of the characterization study should encompass a Friday. Ideally, the accumulation time should match as closely as possible with the normal waste collection cycle at the location.

- ❑ Third, obtain a volume measurement or weight measurement of the waste. In most cases it is not feasible to use scales to determine the actual net weight of the waste in the container, and volume measurements are taken instead. If the measurement is based on volume, then a plan should be developed to obtain a volume-to-weight conversion factor, or *density*, of the waste. A procedure for determining density is presented below. Note the accumulation time that corresponds with the measurement.

- ❑ Fourth, calculate an annual waste generation rate in terms of tons per year or cubic yards per year.

In order to convert a measured volume of waste to an estimated weight, it is necessary to have an estimate of the waste's density. Ideally, the estimate is based on the actual waste that is observed. The recommended procedure for collecting density data is described below.

- ❑ First, obtain or construct one or more *graduated containers* that can be used to measure the volume of a waste sample. Usually, a portable trash can (a "toter") or a plywood box can serve this purpose. Mark the container at intervals on the inside to show the volume of material that has been placed in the container. Determine a method of translating the markings into actual measured volume.

  One method of calibrating the graduated container is to fill it up with successive 5-gallon buckets of sand or water and mark the height after every bucketful. As a conversion factor, one gallon equals 0.00495 cubic yards; one cubic yard equals 202 gallons.

- ❑ Second, obtain a representative sample of waste from one or more of the locations that were identified in the *procedure for quantifying a waste stream at a generator location*, which is described above. Usually, the sample that is obtained for a density measurement is the same sample that is sorted to gather composition data. Place the sample in the graduated container, and note its volume. Try not to compact the waste or allow it to "fluff up" any more than was the case in the dumpster from which it came.

- ❑ Third, weigh the waste sample, either in its entirety or in pieces during the waste sorting process. The density of the waste sample is its weight (pounds) divided by its volume (cubic yards).

The density of waste for each substream at each generator location should be used to extrapolate the weight of waste disposed as part of each substream at each location. In other words, each density figure should be applied to the waste it came from, in order to calculate the tons of waste generated per year.

COLLECTING DATA TO ESTIMATE WASTE COMPOSITION

RECOMMENDED NUMBERS AND SIZES OF SAMPLES

This section presents the recommended numbers and weights of samples for several waste sectors. However, it is important to remember that a waste characterization study represents research into something that is unknown, and it is impossible to predict with certainty how many samples will be "enough" to suit the purposes of the study's designers. The recommended numbers of waste samples and amounts of material to include in waste samples are shown below. Later examination of the error ranges associated with waste composition estimates can serve to indicate whether additional data should be collected.

- Commercial or industrial waste, commercially hauled to disposal facility: 80 to 100 samples of 200 to 250 pounds each
- Commercial or industrial waste, self-hauled to disposal facility: 80 to 100 samples of 200 to 250 pounds each
- Consumer waste, commercially hauled to disposal facility: 40 to 50 samples of 200 to 250 pounds each
- Consumer waste, self-hauled to disposal facility: 80 to 100 samples of 200 to 250 pounds each
- Commercial or industrial waste characterized at the point of generation (e.g., sampled out of the dumpster): 40 to 50 samples of 150 pounds each
- Consumer waste characterized at the point of generation (e.g., sampled out of the trash can): 60 to 80 samples of 125 pounds or the entire contents of the trash can, whichever is less
- Construction and demolition waste: 120 to 180 samples consisting of the entire waste load (making use of visual characterization techniques)

ASTM International has developed a method[2] for predicting the precision in composition estimates in a waste characterization study that involves a given number of samples. The method also can be "used in reverse" to predict the number of samples required in order to yield a desired precision. Used either way, the method requires as input the precision that was obtained in the composition estimate with respect to a particular material in a previous waste characterization study. The method makes use of the following approximate relationship between precision and number of samples.

$$\left(\frac{\text{Confidence Level}_{\text{new}}}{\text{Confidence Level}_{\text{old}}}\right)^2 \times \left(\frac{\text{Confidence Interval}_{\text{old}}}{\text{Confidence Interval}_{\text{new}}}\right)^2 \times \frac{\text{Number of Samples}_{\text{old}}}{\text{Number of Samples}_{\text{new}}} = 1,$$

where *new* refers to the contemplated study and *old* refers to the previously conducted reference study. (Thus, the term $\text{Confidence Interval}_{\text{new}}$ refers to the desired confidence interval for the estimate of the percent of a specific material in the planned study.) See the

[2] "Standard Guide for General Waste Sampling," ASTM Method Paper D 4687 – 95, available from ASTM International, PO Box C700, West Conshohocken, Pennsylvania, USA 19428-2959, www.astm.org

introductory section of the chapter on Calculation Methods for an explanation of *confidence level* and *confidence interval*.

STRATIFICATION OF SAMPLES; ALLOCATION TO SUB-SECTORS

The scenarios described in the above section (*Recommended Numbers and Sizes of Samples*) provide guidelines based on the type of waste and type of study being conducted. When the study involves exactly one type of waste that is carried in vehicles of approximately the same size (or that is deposited in dumpsters that receive waste with approximately the same characteristics), then it is possible to use those guidelines in a straightforward way to determine the number of samples required. In any situation that is more complicated, involving multiple waste sectors, origins, vehicle types, hauler types, or other differences, it is necessary to identify sub-sectors within the waste population and to allocate samples among the sub-sectors. This is called *stratification* of the samples.

Samples should be allocated among subsectors (*strata*) in proportion to the "importance" that each sub-sector of waste holds for the study designers. For example, if the designers wish to make comparisons in waste composition between two sub-sectors, then an equal number of samples should be allocated to each. If it is more important to the study designers to characterize one subsector rather than another, then the important subsector should receive the majority of samples. A sub-sector should not be assigned more samples simply because it represents a greater quantity of waste.

> Example of sample allocation to subsectors (*strata*)
>
> One of the objectives of a particular waste characterization study is to compare the composition of Sub-stream "A", representing 80% of the city's residential disposal, against Sub-stream "B", representing the 20% of disposal that comes from households in the north end that do not have recycling service. In this case, equal numbers of samples should be allocated to each group, even though the amount of waste associated with each group is very different.

SAMPLING PROCEDURES

HAND-SORTING

Before waste sorting begins, the sorting crew should be trained thoroughly in the definitions of the materials used in the characterization study. During the sorting operation, the waste sample should be spread out on a tarp or table, allowing space for each member of the crew to reach in and pull materials out of the sample. Tared containers for different waste sectors should be placed around the sorting area.

In cases where an item is composed of more than one material, the materials should be separated if possible. If the materials cannot be separated, then the item should be classified according to the material that is responsible for the greatest part of the item's weight.

After the entire sample is sorted, each container of material should be weighed to the nearest 1/10th of a pound, the tare weight of the container subtracted, and the net weight recorded on a field form. An example of a field form to record hand-sorted composition data appears in Appendix E.

VISUAL SAMPLING

Visual characterization is more appropriate for certain types of waste, such as construction and demolition waste, that can be highly variable in composition and often contains large pieces of material. The recommended method for conducting visual characterization of waste samples is described below.

- ❑ First, obtain the *net weight* and the *volume* of the waste load. The best volume measurement usually can be obtained while the load is still inside the vehicle that brought it to the disposal facility. When the load is rectangular in shape, its volume should be measured to the nearest half-foot in three dimensions using a tape measure.

- ❑ Second, tip the entire load onto the ground in a location where the visual estimator can safely walk around the load and examine it without interference or danger from other vehicles arriving at the facility.

- ❑ Third, using a form designed for this purpose, the amount of each material in the load should be estimated in terms of the percent it contributes to the total volume of the load.

- ❑ Fourth, the percent-of-volume measurements for each material should be converted to actual volume estimates, based on the known total volume of the load. (This step and subsequent steps can be done at a later time, perhaps during the analysis phase of the study.)

- ❑ Fifth, the volume estimates for each material should be converted to estimated weights using agreed-upon volume-to-weight conversion factors. A partial set of conversion factors is provided in Appendix B.

- ❑ Sixth, the weight estimates for the sample should be added together, and their sum should be compared to the known net weight of the load. Then, all of the weight estimates should be scaled up or down proportionately so their sum agrees with the net weight of the load.

USING EXISTING DATA FOR WASTE CHARACTERIZATION

In some cases, it is possible to construct an estimate of waste that is generated at a particular generator location or that enters a disposal facility simply by adding together known quantities and compositions. This method does not rely on waste samples in the statistical sense of the word, but it is nevertheless a valid way of characterizing waste. The method involves adding up the known amount of each waste material that can be assigned to the generator or facility. Many disposal facilities keep track of the disposal of certain materials, such as used tires, concrete, etc. Likewise, many commercial and industrial locations generate waste materials in relatively pure form, such as food waste, piles of dirt, crop residues, etc., and this material can sometimes be quantified and characterized without resorting to actual waste sorting or statistical sampling.

EQUIPMENT AND SAFETY MEASURES

A recommended list of equipment for use in waste sampling, waste sorting, and vehicle surveying is presented in Appendix C. Measures that can protect the safety of the data collection crew are described in Appendix D, which presents the draft health and safety protocol for use in waste characterization studies, as developed by the State of California.

CALCULATION METHODS

INTRODUCTION

This section describes methods to calculate estimates of the composition and quantity of one or more segments of the waste stream, based on data that has been collected using the methods described earlier in this document. The estimates produced by waste characterization studies often are presented in the format shown below.

Material	Estimated Percent	Confidence Interval	Estimated Tons
Food waste	23.5%	2.1%	36,800

Confidence interval calculated at the 90% confidence level

The *estimated percent* for each material indicates the best estimate possible, given the available data, for the amount of a particular material in the waste stream being addressed.

The *confidence interval* can be thought of as an "error range" surrounding the estimate.

The figure for *estimated tons* simply reflects the application of the estimated percent for the material to the tons of all disposed material that is the focus of the study.

The *confidence level* is chosen by the study designers during their analysis of the data, and it typically is set at 80% or 90%. Increasing the confidence level has the effect of making the confidence interval wider.

The proper way to interpret the example composition estimate shown above is as follows:

> **In the segment of the waste stream we studied, our best estimate of the portion that is food waste is 23.5%. Based on our statistical method for calculating the precision of our estimate, we are 90% certain that the true amount of food waste in the part of the waste stream we sampled is between 21.4% and 25.6% (i.e., we are 90% certain it is within plus or minus 2.1% of our best estimate of 23.5%).**

If a statistical sampling process is not used, then it is not appropriate to attempt to calculate a confidence interval surrounding a composition estimate. For example, if the composition of a segment of the waste stream is obtained essentially by counting everything that is disposed – rather than sampling just a few pieces of the waste stream and extrapolating – then the composition figure becomes a sum of *measurements* rather than a statistically-based *estimate*, and it does not have confidence interval.

QUANTITY CALCULATIONS

It generally is best to quantify each segment of the waste stream before calculating composition estimates, because the quantities are often used as factors in the composition calculations. The recommended methods for quantifying segments of the waste stream are described below.

QUANTIFYING A WASTE SECTOR BASED ON VEHICLE SURVEYS

If the annual tonnage of all waste disposed at the facility is known, then the analyst should use the vehicle survey to determine the portion of annual disposal corresponding to the waste sectors being studied. For a given waste sector, S, the sector tonnage can be calculated from the tonnage, q, found on individual vehicles.

$$\text{sector tons} = \frac{\sum q_{S,\,\text{survey period}}}{\sum q_{\text{all, survey period}}} \times \sum q_{\text{all, annual}}$$

If the annual tonnage of all waste disposed at the facility is not known, then the analyst should extrapolate sector tons directly from the corresponding tons that were counted during the vehicle survey.

$$\text{sector tons} = \sum q_{S,\text{survey period}} \times \frac{\text{operating days in year}}{\text{days in survey period}}$$

Appropriate adjustments should be made for the differences between weekdays and weekends and for any other known shifts in waste disposal patterns across days, weeks, or seasons.

QUANTIFYING A WASTE SECTOR BASED ON MEASUREMENTS AT THE POINT OF GENERATION

The process of quantifying waste for an industry sector involves several steps, starting with the individual measurements of waste taken at the generators that were visited. The general procedure, applicable in most instances, is described below. It should be followed separately for each *size group* that is being studied within a larger commercial group or industry group.

- First, extrapolate the volume of waste disposed using each waste container (or pile or process, etc.) at each generator that was visited.

$$\text{Volume}_{\text{container, annual}} = \text{Volume}_{\text{container, measured}} \times \frac{\text{Generation time}_{\text{annual}}}{\text{Generation time}_{\text{measured}}}$$

where, in most cases,

$$\frac{\text{Generation time}_{\text{annual}}}{\text{Generation time}_{\text{measured}}} = \frac{\text{operating days or hours in year}}{\text{operating days or hours since last pick-up}}.$$

- Second, add together the extrapolated volume of waste disposed in all containers that handle waste belonging to the same waste stream at the location. (Please see the earlier section entitled *Procedures for Identifying the Sample at a Generator Location* for considerations related to defining waste streams at generator locations.)

$$\text{Volume}_{\text{site, annual}} = \sum \text{Volume}_{\text{container, annual}}$$

- Third, calculate the density of the waste at the generator location, based on data from the waste sample.

$$\text{Density}_{\text{site}} = \frac{\text{Weight}_{\text{sample}}}{\text{Volume}_{\text{sample}}}$$

- Fourth, apply the location-specific density figure to calculate the tons of waste disposed annually by the generator.

$$\text{Tons}_{\text{site, annual}} = \text{Volume}_{\text{site, annual}} \times \text{Density}_{\text{site}}$$

- Fifth, calculate a "scale-up factor" for waste generation by the industry and size group. For many commercial sectors, the appropriate scale-up factor is according to the number of employees. For most agricultural sectors, it is according to number of crop acres or number of animals. The example shown below involves calculating *tons per employee*, or TPE for a given size group in the industry. It draws upon data reflecting the disposed tons and employment only at the locations that were visited as part of the study.

$$\text{TPE}_{\text{annual, size group}} = \frac{\sum_{\text{visited sites}} \text{Tons}_{\text{site, annual, size group}}}{\sum_{\text{visited sites}} \text{Employees}_{\text{site, annual, size group}}}$$

- Sixth, calculate the tons disposed from the entire size group in the industry being studied. The example below draws upon data reflecting the total number of employees in the larger population (e.g. countywide, statewide, etc.) of industry members in the appropriate size group.

$$q_{\text{annual, size group}} = \text{TPE}_{\text{annual, size group}} \times \text{Industrywide employment in size group}$$

- Seventh, add the results for the size groups to calculate total tons disposed by the industry.

$$q_{\text{industry}} = \sum q_{\text{size group}}$$

COMPOSITION CALCULATIONS

The composition of the waste corresponding to a sector of the waste stream is calculated using the method described below. The method should be applied separately to each waste sector being studied and to each size group or distinct waste stream within an industry group. (The next section of this chapter describes how results for individual sectors or size groups can be combined to describe the composition of larger segments of the waste stream.)

CALCULATING THE MEAN ESTIMATE

For a given material, j, in all of the relevant samples, i, calculate the ratio, r, of the material weight, m, to the total sample weight, w.

$$r_j = \frac{\sum_i m_{i,j}}{\sum_i w_{i,j}}$$

The calculation should be repeated for each material.

Calculating the error range

For each mean estimate, r_j, calculated as described above, the confidence interval (error range) surrounding the mean estimate is calculated as follows. First, calculate the variance, $\hat{V}_{r_j}$, of the mean estimate.

$$\hat{V}_{r_j} = \left(\frac{1}{n}\right) \times \left(\frac{1}{\overline{w}^2}\right) \times \left(\frac{\sum_i \left(m_{i,j} - r_j w_i\right)^2}{n-1}\right)$$

where n is the number of samples, and the mean sample weight, $\overline{w} = \frac{\sum_i w_i}{n}$.

Next, calculate the confidence interval, which is $\pm\left(t \times \sqrt{\hat{V}_{r_j}}\right)$, where t depends on the number of samples, n, and the desired confidence level. The value of t can be estimated based on the table shown in Appendix F.

Combination of estimates (weighted combinations)

Combining the composition estimates for two or more segments of the waste stream requires the use of a *weighted averages* method. The result for each segment of the waste stream is weighted according to the relative size of that segment in the larger waste stream that is being studied.

Calculating the weighting factors when combining waste sectors

A specific weighting factor should be calculated for each sector or segment of the waste stream being studied. The weighting factor, p_G, for each segment or size group, G, within the waste stream is calculated as follows.

$$p_G = \frac{t_{G,\text{ annual}}}{t_{\text{all sectors, annual}}}$$

A weighting factor should be calculated for every waste sector, and thus the sum of all the values of p_G should equal one.

Calculating the Mean Estimate for Combined Sectors

The mean estimate for a given material, j, in a combination of segments (1, 2, 3...) of the waste stream is found as follows.

$$r_{j,\text{combined}} = (p_1 \times r_{j,1}) + (p_2 \times r_{j,2}) + (p_3 \times r_{j,3}) + \ldots$$

Calculating Variance and Confidence Intervals for Combined Sectors

When a mean estimate for combined waste sectors is calculated as shown above, the variance surrounding the estimate can be calculated as follows.

$$V_{j,\text{combined}} = (p_1^2 \times \hat{V}_{r_j 1}) + (p_2^2 \times \hat{V}_{r_j 2}) + (p_3^2 \times \hat{V}_{r_j 3}) + \ldots$$

The confidence interval is then calculated as $\pm\left(t \times \sqrt{V_{j,\text{combined}}}\right)$.

<u>Variables used in the calculations:</u>

S	tonnage associated with a sector during a particular time period
q	quantity of waste encountered in the study
TPE	tons per employee
j	designation of a particular material
i	designation of a particular sample
r	ratio of material weight to total sample weight, for an individual sample
m	weight of a material in an individual sample
w	total weight of an individual sample
V	the variance associated with the estimate for a material's percent in a group of samples
n	number of samples in the group
p	a weighting factor given to a segment of the waste stream, where the sum of all the values of p is 1
G	designation of a size subgroup within a segment of the waste stream – usually used for generator samples

PRODUCTS OF WASTE CHARACTERIZATION STUDIES

INFORMATION AND ESTIMATES TO BE REPORTED

The most important components of a waste characterization study are described below.

(1) List and definitions of waste sectors addressed in the study, in a way that is consistent with the diagram of waste sectors presented on page 12 of this document.

(2) Count of waste samples that were characterized for each waste sector.

(3) An annual tonnage estimate for each waste sector addressed in the study, if possible.

(4) A description of how waste sectors were combined in order to analyze results for larger segments of the waste stream. Along with this description, the relevant weighting factors associated with the waste sectors should be presented.

(5) Waste composition estimates for each important waste sector or combination of waste sectors, broken out by individual material or combined groups of materials. (Please refer to the list and definitions of materials presented in Appendix A.) An example of the recommended reporting format is shown below.

Material	Estimated Percent	+/–	Annual Tons
Paper	**21.5%**		**69,041**
Newspaper	8.4%	0.8%	26,974
Cardboard	0.6%	0.1%	1,927
Other Groundwood	2.7%	0.3%	8,670
High-Grade Paper	2.2%	0.2%	7,065
Magazines	1.3%	0.1%	4,175
Mixed / Low-Grade Paper	0.7%	0.1%	2,248
Compostable	0.3%	0.1%	963
Residual / Composite Paper	2.3%	0.2%	7,386
Processing Sludges & Other Industrial	3.0%	0.3%	9,634
Plastic	**5.5%**		**17,662**
PET Bottles	0.7%	0.1%	2,248
HDPE Bottles	0.2%	0.1%	642
...etc...	...	...	...
...etc...	...	...	...
Total	**100.0%**		**321,123**

DATA TO BE RECORDED

This section describes the data that should be recorded and retained as part of waste characterization studies. The objective of instituting standards in data recording is to promote the sharing of waste characterization data among communities and to facilitate comparisons of the waste stream in environments with different waste management and recycling policies.

The best way to record and store the data from waste characterization studies is usually in a relational database. Recommended database structures are shown below. However, it also is possible to keep the relevant data in spreadsheets or similar electronic files.

RECORDING DATA FROM VEHICLE SURVEYS

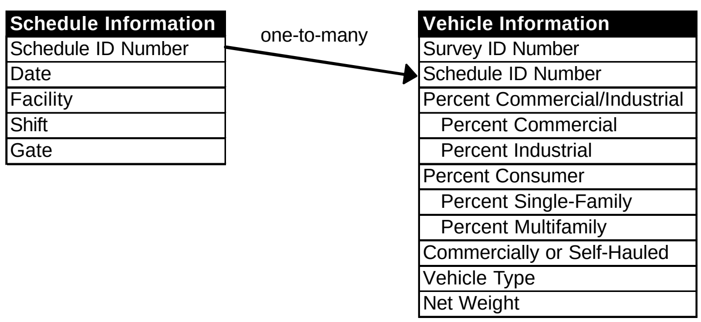
For each day or “session” of the vehicle survey, the following information should be recorded:

- date
- location (name of solid waste facility, etc.)
- gate (if the facility has multiple entrances)

Then, for each vehicle encountered in the survey, the following information should be recorded:

- Percentage of the waste that is from each "origin" (commercial, industrial, consumer, or other). If the waste is of mixed origin, the driver's estimate of the percentage of each type should be recorded.
- Type of hauler (commercial hauler or self-hauler).
- Vehicle type
- Net weight of the waste load
- Other data, as appropriate. Other data may refer to the type of business or industry that generated the waste, the neighborhood from which it came, the type of construction activity associated with it, etc.

A recommended database structure for managing these data is illustrated below.



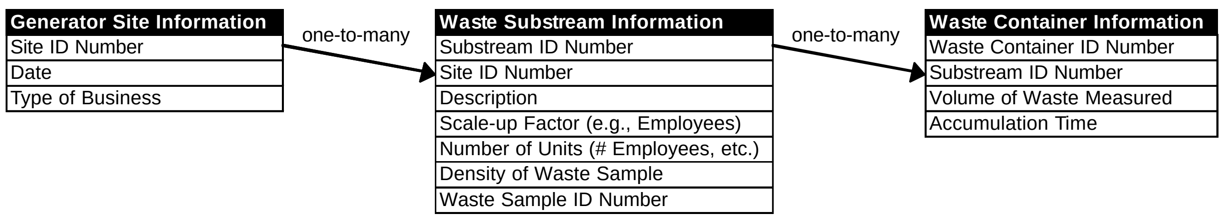
RECORDING WASTE QUANTITY DATA FROM THE POINT OF GENERATION

For each generator location at which waste is quantified, the following information should be recorded:

- Unique identifier for the generator (e.g., business name, or a simple number if data are to be recorded anonymously)
- Date(s) of measurements
- Type of business -- please refer to the list of Standard Industrial Classification (SIC) codes, presented in Appendix G.
- Identification of waste streams at the location, if multiple waste streams exist. For each waste stream, record:
  - Description of waste stream
  - Choice of scale-up factor (e.g., employees, acres, animals, etc.)
  - Number of units of the scale-up factor associated with the waste stream at the location (e.g., number of employees, etc.)
  - Density of the waste sample, if a sample was obtained for this waste stream.

- Identification number of the waste sample, if a sample was obtained for this waste stream.
- Identification of containers, piles, or locations of waste being measured as part of the waste stream at the location. For each, record:
    - Unique identification of the container, pile, or location (e.g., using a numbering system)
    - Volume of waste in the container, pile, etc.
    - Accumulation time associated with the measured amount of waste

A recommended database structure for managing these data is illustrated below.

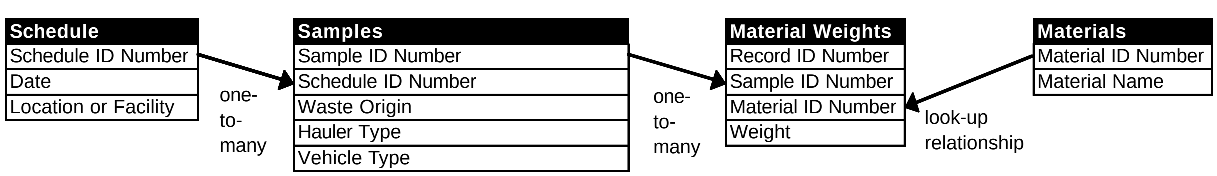


RECORDING WASTE COMPOSITION DATA

For each waste sample, the following information should be recorded:

- Unique ID Number for the sample
- Date when the sample was obtained
- Location (disposal facility, etc.)
- Origin (commercial, industrial, consumer, other)
- Hauler type (commercially hauled or self-hauled)
- Vehicle type
- Other data about the origin or generation of the waste, as appropriate
- Weight of each material in the sample

A recommended database structure for managing these data is illustrated below.



GLOSSARY

class (of generators) – a grouping of waste generators that are believed to produce waste having similar characteristics, or a grouping of waste generators for which there is no research-motivated or policy-based reason to differentiate the waste generators further. For example, all grocery stores may be envisioned as belonging to the same class, because their waste can reasonably be expected to be very similar. As another example, there may be cases when drug stores are rightfully assigned to the same class as grocery stores, because they often occur together in a particular city, and their waste is always collected together.

commercial waste – waste originating from businesses, government agencies, or institutions having SIC "major group" designations ranging from 41 to 97.

composition – the average mixture of materials, usually expressed in terms of percents, found in a clearly defined segment of the waste stream.

confidence interval – a range of values surrounding the *best estimate* of a composition percentage for a material in the waste stream. The confidence interval indicates the range in which the true percentage in the sampled population probably lies, with a probability defined by the *confidence level*. A confidence interval is often referred to as an "error range."

confidence level – an arbitrarily chosen level of certainty that affects the breadth of the *confidence interval*. A higher, more rigorous value for the confidence level implies a wider, less rigorous confidence interval, and *vice versa*. For waste composition estimates, the confidence level is usually defined to be 90% or 80%.

construction and demolition waste – waste originating from businesses engaged in construction or demolition of structures as their primary business activity.

consumer waste – waste originating from households.

destination – the place where solid waste goes. In the framework encouraged by this methodology, the three possible destinations for solid waste are landfilling, beneficial use, or other disposal.

error range – see *confidence interval*.

generator – A waste generator is defined for the purpose of waste characterization studies as any commercial, governmental, institutional, or residential entity that generates waste. The purpose of defining and focusing on waste generators is to gather information that is obscured when waste from different sources (generators) is mixed together as it passes through the solid waste system.

industrial/agricultural waste – waste originating from businesses having SIC “major group” designations ranging from 01 through 39.

load – all of the waste brought to a disposal facility on a single vehicle.

origin – the type of entity that generated the waste in question. In the framework encouraged by this methodology, solid waste is either commercial, industrial/agricultural, or consumer in origin.

material – a set of items and substances that are grouped together for the purpose of the waste characterization study.

multifamily – a set of five or more households that share waste collection service in a common waste container (large trash can, dumpster, or compactor). For the purpose of waste characterization studies, some mobile home parks are classified as multifamily residences.

random selection – selecting items, such as waste loads or waste generators, from the entire set of ones available, without any pattern to the selection.

sample – a portion of waste belonging to a segment of the waste stream and believed to be representative of it, that is sorted or visually characterized to determine its composition.

sampling plan – a plan for data collection that is designed to minimize bias and to ensure that waste composition and quantity data are as representative as possible of the waste stream being addressed in the study.

scale-up factor – a factor that allows projection of waste quantities disposed at the local level (e.g., at the particular generator sites encountered in the study) to a larger level (e.g., to the statewide level).

single-family –households that have individual waste collection, or small groups of two to four households that share waste collection.

size category – a stratification within a class of waste generators, used in cases when the size of the generator is expected to correlate somehow with waste composition or waste generation rates (per-employee or per-acre).

stratification – any subdivision of a segment of the waste stream for the purpose of selecting waste samples. Stratification is used in order to avoid counting things that are clearly different as being the same.

systematic selection – selecting items, such as waste loads or waste generators, by placing them in a list or in some order, and choosing individuals from the list at consistent intervals.

universe – the entire solid waste stream that is considered in a study

vehicle survey – a series of questions administered to vehicle drivers entering a disposal facility, regarding the waste sector and other classification of their waste loads. A vehicle survey is administered to determine the relative quantity of each segment of the waste stream.

visual characterization – estimating the composition of a waste sample by estimating the volume of each material within the sample and a applying volume-to-weight conversion factors to derive composition by weight.

waste sectors – the segments into which the *universe* of solid waste is divided for the purposes of the study at hand.

waste streams – types of waste generated by the same business having different quantity or composition characteristics and placed in separate containers or handled through distinct processes.

weighted combination – combining composition estimates for smaller segments of the waste stream, to produce a composition estimate for a larger segment of the waste stream, while keeping track of the relative magnitude of each of the smaller segments.

APPENDIX A: RECOMMENDED MATERIAL LIST AND DEFINITIONS

PAPER

Newspaper: printed groundwood newsprint, including glossy ads and Sunday edition magazines that are delivered with the newspaper (unless these are found separately during sorting).

Cardboard: unwaxed kraft paper corrugated containers and boxes, unless poly- or foil-laminated. Note that this material includes brown kraft paper bags.

Other Groundwood: other products made from groundwood paper, including phone books, paperback books, and egg cartons.

High-Grade Paper: high-grade white or light-colored bond and copy machine papers and envelopes, and continuous-feed computer printouts and forms of all types, except multiple-copy carbonless paper.

Magazines: magazines, catalogs and similar products with glossy paper.

Mixed / Low-Grade Paper: low-grade recyclable papers, including colored papers, notebook or other lined paper, envelopes with plastic windows, non-corrugated paperboard, carbonless copy paper, polycoated paperboard packaging, and junk mail.

Compostable: Paper cups, pizza boxes and papers that can be composted such as paper towels, tissues, paper plates, and waxed cardboard. This material includes all paper that is contaminated or soiled with food or liquid in its normal use.

Residual / Composite Paper: non-recyclable and non-compostable types of papers such as carbon paper and hardcover books, and composite materials such as paper packaging with metal or plastic parts.

Processing Sludges, Other Industrial: paper-based materials from industrial sources that do not easily fit into the above materials, such as sludges.

PLASTIC

PET Bottles: polyethylene terephthalate (PET) bottles, including soda, oil, liquor and other types of bottles. No attempt will be made to remove base cups, caps, or wrappers, although these materials will be categorized separately if received separately. The SPI code for PET is 1.

HDPE Bottles, Clear: high density polyethylene (HDPE) milk and other bottles that are not colored. The SPI code for HDPE is 2.

HDPE Bottles, Pigmented: high density polyethylene (HDPE) juice, detergent, and other bottles that are colored. The SPI code for HDPE is 2.

Film and Bags: all plastic packaging films and bags. To be counted as this material, the material must be flexible (i.e., can be bent without making a noise).

Bottles Types 3 - 7: all bottles that are not PET or HDPE, where the neck of the container is narrower than the body. Includes SPI codes 3 - 7.

Expanded Polystyrene: packaging and finished products made of expanded polystyrene. The SPI code for polystyrene (PS) is 6.

Other Rigid Plastic Packaging: all plastic packaging that is not a bottle and is not film or bag.

Other Plastic Products: finished plastic products such as toys, toothbrushes, vinyl hose and shower curtains. In cases where there is a large amount of a single type of product, the name of the product should be noted on the data collection form.

Residual / Composite Plastic: other types of plastic that are not one of the above materials and items that are composites of plastic and other materials.

ORGANICS

Yard, Garden and Prunings: grass clippings, leaves and weeds, and prunings six inches or less in diameter.

Food Waste: food waste and scraps, including bones, rinds, etc., and including the food container when the container weight is not appreciable compared to the food inside.

Manures: animal manures and human feces, including kitty litter and any materials contaminated with manures and feces.

Disposable Diapers: disposable baby diapers and protective undergarments for adults (including feminine hygiene products).

Carcasses, Offal: carcasses and pieces of small and large animal, unless the item is the result of food preparation in a household or commercial setting. For instance, fish or chicken entrails from food preparation and raw, plucked chickens will typically be classified as food, not as an animal carcass, unless the material is from an agricultural or industrial source.

Crop Residues: vegetative materials that are left over from growing crops, and that are treated as a waste.

Septage: the liquid or semi-liquid material removed from septic tanks.

Residual / Composite: other organics that do not easily fit into the above materials, must note identity of whatever material is placed in this material.

WOOD WASTES

Natural Wood: wood that is not been processed, including stumps of trees and shrubs, with the adhering soil (if any), and other natural woods, such as logs and branches in excess of six inches in diameter.

Treated Wood: wood treated with preservatives such as creosote, CCA and ACQ. This includes dimensional lumber and posts if treated, but does not include painted or varnished wood. This material may also include some plywood (especially "marine plywood"), strandboard, and other wood.

Painted Wood: wood that has been painted, varnished or coated in similar ways.

Dimensional Lumber: wood commonly used in construction for framing and related uses, including 2 x 4's, 2 x 6's and posts/headers (4x8's, etc.).

Engineered: building materials that have been manufactured and that generally include adhesive as one or more layers. Examples include plywood (sheets of wood built up of two or more veneer sheets glued or cemented together under pressure), particle board (wood chips pressed together to form large sheets or boards), fiberboard (like particle board but with fibers), "glu-lam" beams and boards (built up from dimensional or smaller lumber), and similar products.

Packaging: partial or whole pallets, crates and similar shipping containers.

Other Untreated Wood: other types of wood products and materials that do not fit into the above materials, excluding composite materials (See Residual / Composites, below).

Wood Byproducts: sawdust and shavings, not otherwise identifiable.

Residuals/ Composites: items that consist primarily of wood but that do not fit into the above materials, including composite materials that consist primarily (over 50%) of wood. Examples of composites include wood with sheetrock nailed to it or with tiles glued to it (such that the materials cannot be easily separated)

CONSTRUCTION, DEMOLITION AND LAND CLEARING (CDL) WASTES

Insulation: Include all pad, roll, or blown-in types of insulation. Do not include expanded polystyrene.

Asphalt: asphalt paving material.

Concrete: cement (mixed or unmixed), concrete blocks, and similar wastes.

Drywall: used or new gypsum wallboard, sheetrock or drywall present in recoverable amounts or pieces (generally any piece larger than two inches square will be recovered from the sample).

Soil, Rocks and Sand: rock, gravel, soil, sand and similar naturally-occurring materials.

Roofing Waste: asphalt and fiberglass shingles, tar paper, and similar wastes from demolition or installation of roofs. Does not include wooden shingle or shakes.

Ceramics: includes clay, porcelain bricks and tiles, such as used toilets, sinks and bricks of various types and sizes.

Residual / Composites: other construction and demolition materials that do not fit easily into the above materials or that are composites made up of two or more different materials.

GLASS

Clear Beverage Glass
Green Beverage Glass
Brown Beverage Glass: these are three separate materials for glass bottles and jars that are clear, green or brown in color. Note that blue glass will be included with brown glass.

Other Glass Containers – Clear
Other Glass Containers – Green
Other Glass Containers - Brown: these are three separate materials for bottles and jars that are clear, green or brown in color. Note that blue glass will be included with brown glass.

Plate Glass: flat glass products such as windows, mirrors, and flat products.

Residual / Composite Glass: other types of glass products and scrap that do not fit into the above materials, including light bulbs, glassware and non-C&D fiberglass. Note that ceramics (plates and knickknacks) will not be included here but will be placed in "Non-Glass Ceramics" below.

Non-glass Ceramics: Ceramics not composed of true glass and not typically used as building materials. Examples include Pyrex, dishes, etc.

METAL

Aluminum Cans: aluminum beverage cans.

Aluminum Foil / Containers: aluminum foil, food trays and similar items.

Other Aluminum: aluminum scrap and products that do not fit into the above two materials.

Copper: copper scrap and products, excluding composites such as electrical wire.

Other Non-Ferrous Metals: metallic products and pieces that are not aluminum or copper and not derived from iron (see "other ferrous") and which are not significantly contaminated with other metals or materials (see "residual/composite").

Tin Cans: tin-coated steel food containers. This material includes bi-metal beverage cans, but not paint cans or other types of cans.

White Goods: large household appliances or parts thereof. Special note should be taken if any of these are found still containing refrigerant.

Other Ferrous: products and pieces made from metal to which a magnet will adhere (but including stainless steel), and which are not significantly contaminated with other metals or materials (in the latter case, the item will instead be included under "residual/composite"). This material will include paint and other non-food "tin cans", as well as aerosol cans.

Residual / Composite: items made of a mixture of ferrous and non-ferrous or a mixture of metal and non-metallic materials (as long as these are primarily metal). Examples include small appliances, motors, and insulated wire.

CONSUM ER PRODUCTS

Computers: computers and parts of computers, including monitors, base units, keyboards, other accessories and laptops.

Other Electronics: other appliances and products that contain circuit boards and other electronic components (as a significant portion of the product), such as televisions, microwave ovens and similar products.

Textiles, Synthetic: cloth, clothing, and rope made of synthetic materials.

Textiles, Organic: cloth, clothing, and rope made of 100% cotton, leather, wool or other naturally-occurring fibers. Composites of several different naturally-occurring fibers (such as a wool jacket with a cotton liner) can be included in this material, but not if the item has zippers or buttons made from a different material. The working guideline for this material should whether the item could be composted without leaving an identifiable residue or part.

Textiles, Mixed or Unknown: cloth, clothing, and rope made of unknown fibers or made from a mixture of synthetic and natural materials, or containing non-textile parts such as metal zippers or plastic buttons.

Shoes: all shoes and boots, whether made of leather, rubber, other materials, or a combination thereof.

Tires and Other Rubber: vehicle tires of all types, including bicycle tires and including the rims if present, and finished products and scrap materials made of rubber, such as bath mats, inner tubes, rubber hose and foam rubber (except carpet padding, see below).

Furniture and Mattresses: furniture and mattresses made of various materials and in any condition.

Carpet: pieces of carpet and rugs made of similar material.

Carpet Padding: foam rubber and other materials used as padding under carpets.

Rejected Products: for industrial samples only, various products that failed internal QA/QC tests.

Returned Products: for industrial samples only, various products that were returned by the consumer who purchased the item.

Other Composite: This is a catch-all material for objects consisting of more than one material.

RESIDUALS

Ash: fireplace, burn barrel or firepit ash, as well as boiler and ash from industrial sources.

Dust: baghouse and other dusts from industrial sources, as well as bags of vacuum cleaner dust.

Fines / Sorting Residues: mixed waste that remains on the sorting table after all the materials that can practicably be removed have been sorted out. This material will consist primarily of small pieces of various types of paper and plastic, but will also contain small pieces of broken glass and other materials. May also include material less than one-half inch in diameter that falls through a bottom screen during sorting, for those using sorting boxes with screens, and if the material cannot otherwise be identified.

Sludges and Other Special Industrial Wastes: sludges and other wastes from industrial sources that cannot easily be fit into any of the above material. Can include liquids and semi-solids but only if these materials are treated as a solid waste.

HAZARDOUS AND SPECIAL WASTES

Used Oil: used or new lubricating oils and related products, primarily those used in cars but possibly also including other materials with similar characteristics.

Oil Filters: used oil filters, primarily those used in cars but possibly including similar filters from other types of vehicles and other applications.

Antifreeze: automobile and other antifreeze mixtures based on ethylene or propylene glycol, also brake and other fluids if based on these compounds.

Auto Batteries: car, motorcycle, and other lead-acid batteries used for motorized vehicles.

Household Batteries: batteries of various sizes and types, as commonly used in households.

Pesticides and Herbicides: includes a variety of poisons whose purpose is to discourage or kill pests, weeds or microorganisms. Fungicides and wood preservatives, such as pentachlorophenol, are also included in this material.

Latex Paint: water-based paints.

Oil Paint: solvent-based paints.

Medical Waste: wastes related to medical activities, including syringes, IV tubing, bandages, medications, and other wastes, and not restricted to just those wastes typically classified as pathogenic or infectious.

Fluorescent Tubes: in addition to the typical fluorescent tubes (including fluorescent light bulbs and other forms), this material includes mercury vapor and other lamps listed as universal wastes.

Asbestos: pure asbestos, and asbestos-containing products where the asbestos present is the most distinguishing characteristic of the material.

Other Hazardous Waste: problem wastes that do not fall into one of the above material, such as gasoline, solvents, gunpowder, other unspent ammunition, fertilizers, and radioactive materials.

Other Non-Hazardous Waste: problem wastes that do not fall into one of the above materials, but that are not hazardous, such as adhesives, weak acids and bases (cleaners), automotive products (car wax, etc.)

APPENDIX B: VOLUME-TO-WEIGHT CONVERSION FACTORS

The following table provides material density estimates for use in visual waste characterization methods. When data is not available or has not yet been found by Cascadia Consulting Group, entries are left blank. It is important to note that the density figures presented here are estimates intended for use as “rules of thumb.” Situations often exist where the actual density of each material differs from the figure presented here.

Material	Density (lbs per cubic yard)	Source
Paper		
Newspaper	400	EPA Business Guide
Cardboard	50	Tellus
Other Groundwood	250	EPA Government Guide
High-Grade Paper	364	Tellus
Magazines	400	EPA Government Guide
Mixed / Low-Grade Paper	364	EPA Government Guide
Compostable Paper	903	Cascadia
Remainder/Composite Paper		
Process Sludge / Other Industrial Sludge		
Plastic		
PET Bottles	35	EPA Government Guide
HDPE Bottles, CLEAR	24	EPA Government Guide
HDPE Bottles, COLORED	24	EPA Government Guide
Film and Bags	23	Tellus
Bottles Types 3 - 7		
Expanded Polystyrene	22	Tellus
Other Rigid Plastic Packaging	50	EPA Government Guide
Other Plastic Products		
Remainder/Composite Plastic	50	EPA Government Guide
Organics		
Yard, Garden and Prunings	108	EPA Business Guide
Food Waste	1,443	Tellus
Manures	1,628	Tellus
Disposable Diapers		
Carcasses, Offal		
Crop Residues	910	Cascadia
Septage		
Remainder/Composite Organics		

Material	Density (lbs per cubic yard)	Source
Wood Wastes		
Natural Wood	330	CIWMB
Treated Wood	330	CIWMB
Painted Wood	330	CIWMB
Dimensional Lumber	330	Tellus
Engineered	425	Tellus
Packaging		
Other Untreated Wood	330	CIWMB
Wood Byproducts	375	Tellus
Remainder/Composite Wood		
Construction, Demolition & Landclearing Wastes		
Insulation	17	CIWMB
Asphalt	1,215	FEECO
Concrete	2,700	FEECO
Drywall	394	Tellus
Soil, Rocks & Sand	2,200	Average of CIWMB figures
Roofing Waste	600	Average of figures from San Diego, CIWMB, Cascadia
Ceramics	320	Cascadia measurement
Remainder/Composite C&D		
Glass		
Clear Beverage Glass	600	EPA Government Guide
Green Beverage Glass	600	EPA Government Guide
Brown Beverage Glass	600	EPA Government Guide
Clear Container Glass	600	EPA Government Guide
Green Container Glass	600	EPA Government Guide
Brown Container Glass	600	EPA Government Guide
Plate Glass	1,000	EPA Government Guide
Remainder/Composite Glass	1,000	EPA Government Guide
Non-glass Ceramics		
Metal		
Aluminum Cans	91	Tellus
Aluminum Foil / Containers		
Other Aluminum	175	Tellus
Copper	1,094	Tellus
Other Non-Ferrous Metals		
Tin Cans	850	EPA Business Guide
White Goods	180	EPA Government Guide
Other Ferrous	906	EPA Business Guide
Remainder/Composite Metals		

Material	Density (lbs per cubic yard)	Source
Consumer Products		
Computers	440	Cascadia
Other Electronics	440	Cascadia
Textiles, SYNTHETIC		
Textiles, ORGANIC		
Textiles, MIXED/Unknown		
Shoes		
Tires & Other Rubber	380	Cascadia
Furniture & Mattresses		
Carpet	305	San Diego
Carpet Padding		
Rejected Products	340	FEECO
Returned Products		
Other Composite		
Residuals		
Ash	1,000	FEECO
Dust		
Fines / Sorting Residues	2,700	Tellus
Sludge & Other Indust.		
Hazardous and Special Wastes		
Used Oil		
Oil Filters	200	Minnesota
Antifreeze		
Auto Batteries		
Household Batteries		
Pesticides & Herbicides		
Latex Paint	1,600	Cascadia
Oil Paint	1,200	Cascadia
Medical Waste		
Fluorescent Tubes	300	Cascadia
Asbestos		
Other Hazardous Waste		
Other Non-hazardous Waste		

Sources of Density Estimates:

EPA Business Guide – Business Waste Prevention Quantification Methodologies - Business Users Guide: Washington, D.C. and Los Angeles: U.S. Environmental Protection Agency, Municipal and Industrial Solid Waste, and University of California at Los Angeles Extension, Recycling and Municipal Solid Waste Management Program, 1996. Grant Number CX 824548-01-0.

EPA Government Guide – Measuring Recycling: A Guide For State and Local Governments. Washington, D.C.: U. S. Environmental Protection Agency, 1997: Phone 1-800-424-9346; http://www.epa.gov. Publication number EPA530-R-97-011.

FEECO -- FEECO International Handbook, 8th Printing (Section 22-45 to 22-510). Green Bay, Wisconsin: FEECO International, Inc. Phone (920) 468-1000; FAX (920) 469-5110.

Tellus – Conversion Factors for Individual Material Types Submitted to California Integrated Waste Management Board. Cal Recovery Inc., Tellus Institute, and ACT…now, December 1991.

San Diego – conversion factors developed and used in *Waste Composition Study 1999-2000: Final Report*, prepared by Cascadia Consulting Group for the City of San Diego's Environmental Services Department, 2000.

Cascadia – figures based on measurements of the pure material conducted by Cascadia Consulting Group

APPENDIX C: EQUIPMENT LISTS

This appendix presents recommended lists of equipment to use when gathering and sorting samples and when conducting vehicle surveys.

EQUIPMENT FOR SAMPLING AND SORTING WASTE

Laundry baskets	Safety glasses
Boots	Sorting tables
Gloves	Clipboards
Hard hats	Hand warmers
Orange safety vests	Hand wipes
Stapler	Calculator
Duct tape	Rain gear
Shovels	Safety vests
Broom	96-gallon toters
Tarps	Waste Composition Field Forms
Scale	First aid kit
Dust masks	2-way radio to communicate with surveyor

EQUIPMENT FOR CONDUCTING VEHICLE SURVEYS

Map and directions to the solid waste facility

Schedule of days, locations

Cell phone

Calling card, for locations out of cell phone range

Plenty of *Vehicle Survey Forms* and pre-printed *Load Selection Forms* specific to the site and day

Numbered cards for net weights

Clipboard with plastic sheet to protect forms from rain

Extra pencils and pens

Language translation cards

Rubber/plastic box to contain survey forms

Hard hat

Safety vest

Apron with pockets

Comfortable & waterproof shoes

Foldable chair (optional)

Raingear, head to toe (where appropriate)

Heavy jacket (where appropriate)

Two pair socks for cold weather (where appropriate)

Sun hat or cold weather hat

Gloves (fingerless work well for writing)

Thermos for tea, coffee of soup

Snacks, hearty lunch (some of the locations are isolated)

Sunglasses

Sunscreen

Radio or something to read if traffic is light

2-way radio to communicate with sampling crew

APPENDIX D: HEALTH AND SAFETY MEASURES

This section presents the Draft Health and Safety Protocol for use in waste characterization studies, as developed by the State of California.

DRAFT HEALTH AND SAFETY PROTOCOL

Date: April 7, 1995

ARTICLE 6.0 DISPOSAL CHARACTERIZATION STUDIES

Health and Safety Guidelines for Waste Characterization Studies

1. **Introduction:**

The purpose of this document is to provide safety guidelines for performing visual and/or physical characterizations of non-hazardous solid waste from various selected garbage dumpsters, transfer stations, and sanitary landfills.

2. **Table of Contents:**

1.0 Introduction
2.0 Table of Contents
3.0 Specific procedure
    3.01 List of Potential Hazards
    3.02 Recommended Personal Safety/Protective Equipment
    3.03 Responsible Personnel
    3.04 General Safety Procedures
    3.05 Site Control in Work Zones
    3.06 Site Resources and personnel
    3.07 Site Maps
    3.08 Agreement to Comply with the Health and Safety Plan

3. **Specific Procedure:**

3.01 List of potential hazards

The following section lists some possible hazards that may occur during a visual and a physical sort of solid waste.

a. Physical hazards:

Cuts and punctures from handling hazardous materials: hypodermic needles, broken glass, razor blades, aerosol cans, chemicals, biohazards, bottles of unknown/unlabeled substances, plastic bottles containing used syringes, and other hazardous materials
Back injury
Slipping and falling
Heat stress and fatigue
Traffic or heavy equipment movement
Noise exposure from operation of heavy equipment
Animal and/or insect bites

b. Airborne contaminants:

Dust from solid waste

c. Chemical hazards:

Liquid spills from containers
Household and hazardous chemicals

d. Biological hazards:

Household hazardous wastes
Medical wastes and sharps
Bloody rags or objects
Hypodermic needles

3.02 Recommended personal safety/protective equipment

The following section lists some of the personal safety/protective equipment recommended for a visual and physical sort of solid waste.

a. Body protection:

Tyvek or equivalent, disposable coveralls
Chemical resistant coveralls, if appropriate
Hard bottomed, non-slip, steel toe boots
A supply of outer rubber (cut and puncture resistant) gloves
Chemical goggles or safety glasses with splash shields
Dust masks
A supply of inner (latex) gloves
Snake guards, if appropriate
Insect repellent
Dog repellent

b. Hearing protection (if site has equipment or activities that generate loud noises):

Ear plugs
Ear muffs

c. Other safety equipment:

Supportive back belt for heavy lifting
Industrial first aid kit
Field blanket
Eye wash kit
Moist, disposable towelettes (e.g., baby wipes)
Six foot pole
Small fire extinguisher
Portable telephone
High visibility traffic cones and tapes
Site specific safety plan
Liquids to replenish fluids (water and cups for dehydration)

3.03 Responsible personnel

The following section lists some of the duties and responsibilities of personnel who are supervising and conducting a visual/physical sort of solid waste.

a. Supervising, Project Manager's duties and responsibilities:

Delegate health and safety responsibilities to the Site Safety Officer, ensure that proper procedures are implemented by qualified personnel in a safe manner, make available proper personal protective equipment, adequate time, and budget.

Ensure that all field personnel have read, understood, and signed the master copy of this document.

Check that all the site personnel have received, and documented training on waste characterization methods, recognizing hazardous wastes, potential risks from handling hazardous materials, managing site traffic, controlling dust/airborne contaminants, and back injury prevention.

b. Site Safety Officer's (can be the same person as above) duties and responsibilities:

Has the duty and authority to stop unsafe operations, supervise CPR, and decide when to summon emergency services.

Ensure that the guidelines, rules, and procedures in this document are followed for all site work.

Be familiar with local emergency services, and maintain a list of emergency phone numbers. Provide a map with the quickest route to a medical facility.

Conduct daily tailgate health and safety meetings before each shift, and a daily summary meeting at the end of each shift to discuss the day's safety issues, possible solutions, and notify personnel of all changes associated with health, safety, and protocol.

Maintain and inspect personal protective equipment. Ensure proper use of personal protective equipment by all employees.

Monitor on site hazards and the early health warning signs (e.g., heat stress/stroke, dehydration, or fatigue) of site personnel. It is recommended that on hot days, outdoor sampling should be done during the early hours.

Has completed appropriate health and safety training. (Recommended: 40-hour Hazardous Waste Operation & Emergency response, CCR, T8, Section 5192-OSHA).

3.04 General safety procedures

The following section lists some of the general safety procedures recommended for a visual/physical sort of solid waste.

a. All waste sorting personnel should: be in good physical condition, have had a recent medical exam, maintain a current tetanus booster and Hepatitis B shot, not be sensitive to odors and dust, and be able to read warning signs/labels on waste containers.

b. There will be absolutely no eating, smoking or drinking during sorting activities. Food and liquids are to be away from the sorting area. Plenty of fluids (e.g., water, sports drinks, etc.) and single use, disposable cups must be available at all times. Hands and faces should be washed before eating or drinking. Consume drinks and rest frequently during hot days.

c. The "line of sight buddy system" must always be maintained at the sorting site. The "line of sight buddy system" is as follows: sorters are grouped into pairs and each member is to periodically assess the physical condition of his/her "buddy".

d. Always wear the following before beginning the sorting procedure: both pairs of gloves (outer rubber and inner latex), chemical goggles or safety glasses with splash shields, a dust mask, and disposable Tyvek overalls. Use safety boots especially when getting into bins.

e. Make noise when approaching the actual waste site to allow any wildlife/pest animals to flee. Look for snakes and poisonous spiders around and inside a dumpster/bin by probing with a long stick.

f. Do not attempt to identify unknown chemical substances present in the waste stream: vials of chemicals, unlabeled pesticide/herbicide containers, and substances (e.g., chemicals, or needles) in unlabeled plastic/glass bottles/jugs.

g. Household hazardous wastes are those wastes resulting from products purchased by the public for household use which because of their quantity, concentration, physical, or infectious, characteristics, may pose a substantial known or potential hazard to human or environmental health when improperly disposed. Empty containers of household hazardous wastes are generally not considered to be a hazardous waste. If hazardous wastes are detected, the Site Safety Officer will be notified.

h. Hazardous materials and hazardous wastes should not be present in non-residential sources of municipal solid waste. If hazardous wastes are present in the municipal waste stream, from a commercial or industrial source, the material is not a household hazardous waste, it is a hazardous waste and the Site Safety Officer must be notified.

i. Biohazardous wastes are generally disposed of in red, plastic bags. Treated biohazardous wastes (by incineration, autoclave, chemical sterilization, etc.), are also usually in red bags. If biohazardous wastes are detected, the sort will be halted (the bag will not be removed from the dumpster/bin) and the Site Safety Officer must be notified.

j. A potential hazard that can arise in waste sampling is the presence of biohazardous wastes that are not in red bags, referred to as "fugitive regulated wastes". Sorters must be on alert for the indicators of fugitive biohazardous wastes: hypodermic needles, needle covers, medical tubing, articles contaminated with red (blood) colored substances, and medical device packaging. If fugitive biohazardous wastes are detected, the sort will be halted and the Site Safety Officer notified.

k. When sorting glass, remove the large pieces first, then remove the clear glass. Never use your hands to dig down through the waste. Use a rake or small shovel to pull/push the material to the side and continue sorting.

l. At the end of each shift, remove all disposable clothing into a plastic trash bag, and place the bag into a solid waste receptacle. All sorters must shower at the end of each shift.

3.05 Site control in work zones

The following section lists site control recommendations for a visual/physical sort of solid waste.

a. Traffic cones or high visibility warning tape will be placed around the active sorting area.

b. Each work crew will keep a site specific safety plan on site at all times.

3.06 Site resources and personnel

The following section lists available site contacts and resources for a visual/physical sort of solid waste.

a. On-site contact:

Main point of contact: ___________________________________

Telephone number: _____________________________________

Facility manager: ______________________________________

Telephone number: _____________________________________

b. Site resources locations

Toilet facilities: ____

____

Drinking water: ____

____

Telephone: ____

____

c. Medical information:

Local emergency medical facility: _________________________

Fire Dept. phone number: _______________________________

Police Dept. phone number: _____________________________

Local ambulance phone number: _________________________

3.07 Site maps

See attachments for a site map that shows the location of local medical facilities.

3.08 Agreement to comply with the health and safety plan

I ____ have read and understand
print name
the health and safety plan and will follow the procedures and protocols detailed in the plan for waste characterization at all designated sites.

APPENDIX E: EXAMPLE OF WASTE COMPOSITION FIELD FORM

EXAMPLE FORM FOR RECORDING MATERIAL WEIGHTS IN A SAMPLE

PAPER	Weight	METAL	Weight	WOOD WASTES	Weight
Newspaper		Aluminum Cans		Natural Wood	
Cardboard		Aluminum Foil / Containers		Treated Wood	
Other Groundwood		Other Aluminum		Painted Wood	
High-Grade Paper		Copper		Dimensional Lumber	
Magazines		Other Non-Ferrous Metals		Engineered	
Mixed / Low-Grade Paper		Tin Cans		Packaging	
Compostable		White Goods		Other Untreated Wood	
R / C Paper		Other Ferrous		Wood Byproducts	
Process Sludge / Other Indust.		R / C Metals		R / C Wood	
PLASTIC		**ORGANICS**		**CONSUMER PRODUCTS**	
PET Bottles		Yard, Garden and Prunings		Computers	
HDPE Bottles, CLEAR		Food Waste		Other Electronics	
HDPE Bottles, COLORED		Manures		Textiles, SYNTHETIC	
Film and Bags		Disposable Diapers		Textiles, ORGANIC	
Bottles Types 3 - 7		Carcasses, Offal		Textiles, MIXED/Unknown	
Expanded Polystyrene		Crop Residues		Shoes	
Other Rigid Plastic Packaging		Septage		Tires & Other Rubber	
Other Plastic Products		R / C Organics		Furniture & Mattresses	
R / C Plastic		**RESIDUALS**		Carpet	
GLASS		Ash		Carpet Padding	
CLEAR Beverage		Dust		Rejected Products	
GREEN Beverage		Fines / Sorting Residues		Returned Products	
BROWN Beverage		Sludge & Other Indust.		Other Composite	
Clear CONTAINER		**CDL WASTES**		**HAZARDOUS / SPECIAL**	
Green CONTAINER		Insulation		Used Oil	
Brown CONTAINER		Asphalt		Oil Filters	
Plate Glass		Concrete		Antifreeze	
R / C Glass		Drywall		Auto Batteries	
Non-glass Ceramics		Soil, Rocks & Sand		Household Batteries	
		Roofing Waste		Pesticides & Herbicides	
		Ceramics		Latex Paint	
		R / C C&D		Oil Paint	
				Medical Waste	
				Fluorescent Tubes	
				Asbestos	
				Other Haz Waste	
				Other Non-Haz Waste	

Location:

Date:

Sample ID:

Notes:

Commercial/Industrial Sample

Business Name/Description:

Record VOLUME of load:

Length: inches

Width: inches

Height: inches

LOAD INFORMATION

Generator Type:

Consumer

Commercial

Industrial

Vehicle Type:

Packer

Drop Box

Other Large

Other Small

Hauler Type:

Commercially Hauled

Self-hauled

Load Net Weight: ______

Load Net Volume: ______

APPENDIX F: VALUES OF THE *t*-STATISTIC

The value of *t* can be estimated based on number of samples, *n*, and the desired confidence level.

Values of *t*

	Confidence Level		
n-2	80%	90%	95%
1	3.078	6.314	12.706
2	1.886	2.920	4.303
3	1.638	2.353	3.182
4	1.533	2.132	2.776
5	1.476	2.015	2.571
6	1.440	1.943	2.447
7	1.415	1.895	2.365
8	1.397	1.860	2.306
9	1.383	1.833	2.262
10	1.372	1.812	2.228
11	1.363	1.796	2.201
12	1.356	1.782	2.179
13	1.350	1.771	2.160
14	1.345	1.761	2.145
15	1.341	1.753	2.131
16	1.337	1.746	2.120
17	1.333	1.740	2.110
18	1.330	1.734	2.101
19	1.328	1.729	2.093
20	1.325	1.725	2.086
21	1.323	1.721	2.080
22	1.321	1.717	2.074
23	1.319	1.714	2.069
24	1.318	1.711	2.064
25	1.316	1.708	2.060
26	1.315	1.706	2.056
27	1.314	1.703	2.052
28	1.313	1.701	2.048
29	1.311	1.699	2.045
30	1.310	1.697	2.042
40	1.303	1.684	2.021
50	1.299	1.676	2.009
60	1.296	1.671	2.000
80	1.294	1.667	1.994
100	1.290	1.660	1.984
1,000	1.282	1.646	1.962
8	1.282	1.645	1.960

APPENDIX G: RECOMMENDED GROUPING OF INDUSTRY TYPES FOR WASTE GENERATOR STUDIES

Description of Group	SIC Codes Included	SIC Code Designations
Agriculture / Fisheries	01	Agricultural production- crops
	02	Agricultural production- livestock
	07	Agricultural services
	09	Fishing, hunting, and trapping
Forestry	08	Forestry
Mining	10	Metal mining
	12	Coal mining
	13	Oil and gas extraction
	14	Nonmetallic minerals, except fuels
Construction	15	General building contractors
	16	Heavy construction contractors
	17	Special trade contractors
Manufacturing - Food / Kindred	20	Food and kindred products
Manufacturing - Other	21	Tobacco manufactures
	29	Petroleum and coal products
	30	Rubber and miscellaneous plastics products
	31	Leather and leather products
	32	Stone, clay, glass, and concrete products
	39	Miscellaneous manufacturing industries
Manufacturing - Apparel / Textile	22	Textile mill products
	23	Apparel and other textile products
Manufacturing - Lumber & Wood Products	24	Lumber and wood products
Manufacturing - Furniture / Fixtures	25	Furniture and fixtures
Manufacturing - Paper / Allied	26	Paper and allied products

Description of Group	SIC Codes Included	SIC Code Designations
Manufacturing - Printing / Publishing	27	Printing and publishing
Manufacturing - Chemical / Allied	28	Chemicals and allied products
Manufacturing - Primary / Fabricated Metal	33	Primary metal industries
	34	Fabricated metal products
Manufacturing - Industrial / Machinery	35	Industrial machinery and equipment
Manufacturing - Electronic Equipment	36	Electrical and electronic equipment
Manufacturing - Transportation Equipment	37	Transportation equipment
Manufacturing - Instruments / Related	38	Instruments and related products
Transportation - Other	40	Railroad operation
	41	Local and interurban passenger transit
	44	Water transportation
	46	Pipelines, except natural gas
	47	Transportation services
Trucking & Warehousing	42	Motor freight transportation and warehousing
Transportation - Air	45	Transportation by air
Communications	48	Communications
Utilities	49	Electric, gas, and sanitary services
Wholesale Trade - Durable Goods	50	Wholesale trade--durable goods
Wholesale Trade - Nondurable Goods	51	Wholesale trade--nondurable goods
Retail Trade - Building Material & Garden	52	Building materials, hardware, garden supply, & mobile
Retail Trade - General Merchandise Store	53	General merchandise stores
Retail Trade - Food Store	54	Food stores
Retail Trade - Automotive Dealers & Service Stations	55	Automotive dealers and gasoline service stations
Retail Trade - Other	56	Apparel and accessory stores
	57	Furniture, home furnishings and equipment stores
	59	Miscellaneous retail
Retail Trade - Restaurants	58	Eating and drinking places

Description of Group	SIC Codes Included	SIC Code Designations
Finance / Insurance / Real Estate / Legal	60	Depository institutions
	61	Nondepository credit institutions
	62	Security, commodity brokers, and services
	63	Insurance carriers
	64	Insurance agents, brokers, and service
	65	Real estate
	67	Holding and other investment offices
	81	Legal services
Services - Hotels / Lodging	70	Hotels, rooming houses, camps, and other lodging places
Services - Other Misc.	72	Personal services
	75	Automotive repair, services, and parking
	76	Miscellaneous repair services
	79	Amusement and recreational services
	83	Social services
	84	Museums, art galleries, botanical & zoological garden
Services - Business Services	73	Business services
Services - Motion Pictures	78	Motion pictures
Services - Medical / Health	80	Health services
Services - Education	82	Educational services
Services - Other Professional	86	Membership organizations
	87	Engineering and management services
	89	Miscellaneous services
Public Administration	43	U.S. Postal Service
	91	Executive, legislative, and general government
	92	Justice, public order, and safety
	93	Finance, taxation, and monetary policy
	94	Administration of human resources
	95	Environmental quality and housing
	96	Administration of economic programs
	97	National security and international affairs